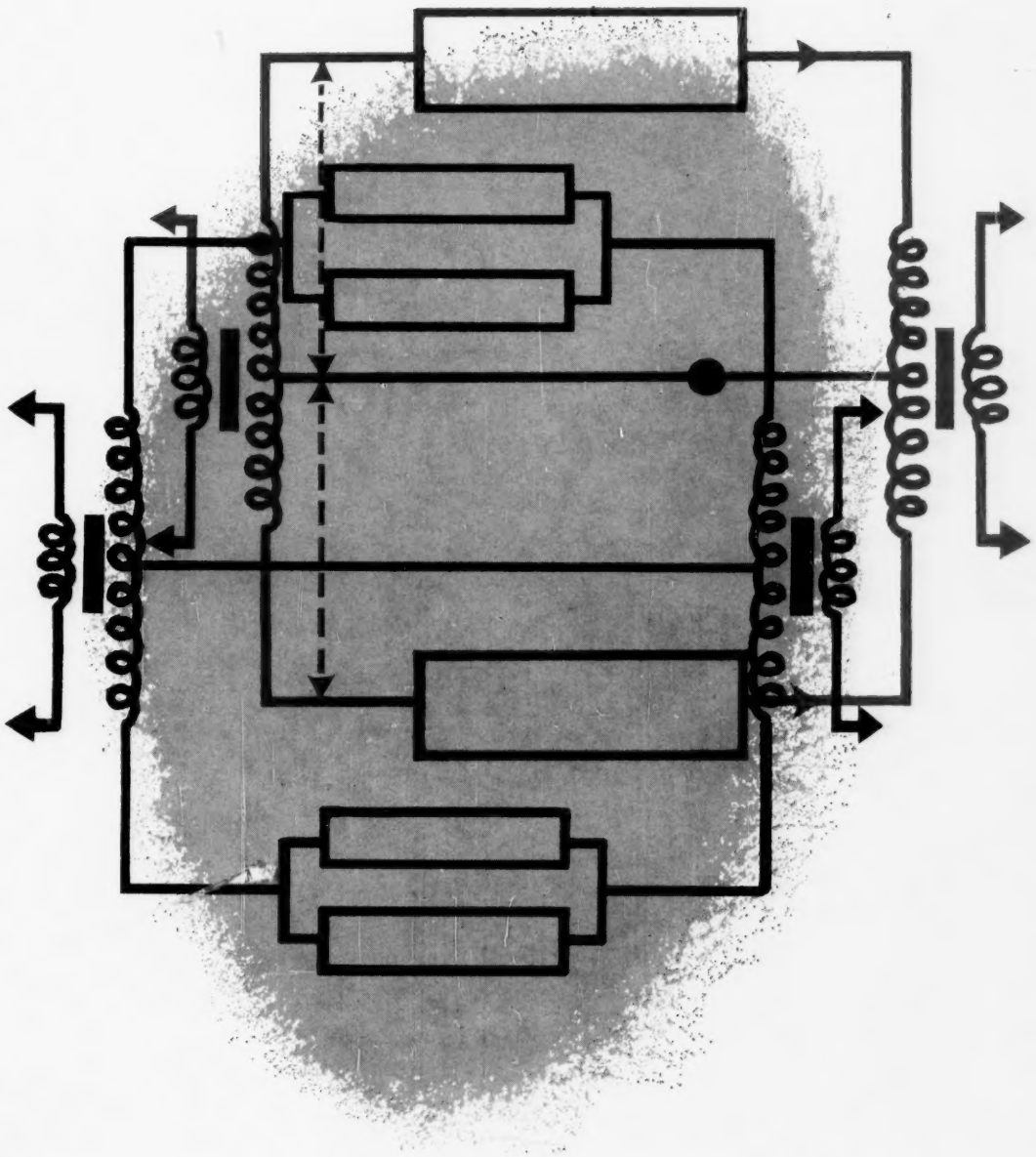
INSTRUMENTS AND CONTROL SYSTEMS

JANUARY 1961 INCLUDING: JOURNAL OF THE SCMA • PRECISION MEASUREMENTS ASSOCIATION • SIMULATION COUNCIL NEWSLETTER



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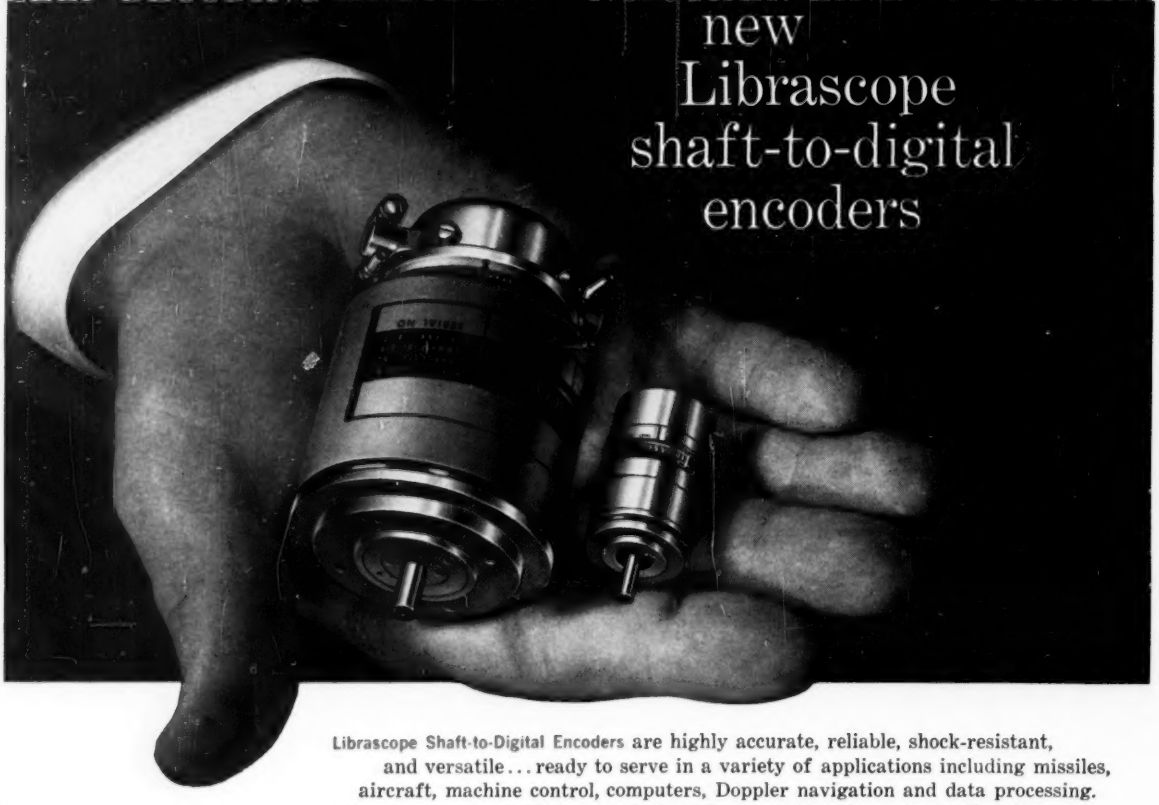
NO OTHER LINE SO COMPLETE · 38 NEW ENCODER MODELS · SIZE 8 ENCODERS · MAGNETIC · SINE/COSINE · GRAY · SELF-DECODING

new Librascope shaft-to-digital encoders



Librascope Shaft-to-Digital Encoders are highly accurate, reliable, shock-resistant, and versatile... ready to serve in a variety of applications including missiles, aircraft, machine control, computers, Doppler navigation and data processing. **Accuracy that counts** is the by-word of a Librascope Encoder... backed by the superior technology and reputation of one of the world's largest producers of *Computers that Pace Man's Expanding Mind.*

new noncontact magnetic encoder

MODEL NO. 807

FEATURES:
Long life, high reliability, high speed, natural binary V-Scan readout.

SPECIFICATIONS:
Output Code: natural binary
Resolution: (per input shaft turn) 128 counts
Full Scale Capacity: 7 bits*
Speed: operating from 0 to 10,000 rpm
Life Expectancy: 20,000 hours at 4,000 rpm; 4 x 10^9 revolutions
Starting Torque: 0.1 in-oz. max.
Diameter: 2"
Length: 1 13/16"
Weight: 5 ounces

*ALSO AVAILABLE IN 13, 17, AND 19 BIT CAPACITIES.

new subminiature size 8 encoder

MODEL NOS. 787 & 793

FEATURES:
Low torque, low inertia, long life, high reliability, withstands severe environments.

SPECIFICATIONS:
Output Code: natural binary
Resolution: (per input shaft turn) 128 counts
Full Scale Capacity: 7 bits, 13 bits
Speed: operating 200 rpm, slew 600 rpm
Life Expectancy: 2 x 10^6 revolutions at 200 rpm
Starting Torque: 0.5 oz-in. maximum
Diameter: .750"
Weight: 3 ounces

other popular Librascope encoders

Code	Model no.	Full scale capacity	Resolution per input shaft turn
Binary	773	13 bits	128 counts
	0-773	oil-filled unit for increased life	
Binary	[illegible]	10 bits	1024 counts
Binary	707 (707D*)	7 bits	128 "
	713 (713D*)	13 bits	128 "
	717 (717D*)	17 bits	128 "
	719 (719D*)	19 bits	128 "
	0-713	oil-filled unit for increased life	
Self-Decoding Binary	740	10 bits	1024 counts
B/C/D	723 (723D*)	2,000 counts	200 "
	724 (724D*)	20,000 "	200 "
	733 (733D*)	3,600 "	200 "
	734 (734D*)	36,000 "	200 "
	735	360,000 "	200 "
Sine/Cosine	757-S**	4 quadrants per turn	7 bits per quadrant + limit 1
	758 758-S**	4 quadrants per turn	8 bits per quadrant + limit 1
Gray	708	8 bits	256 counts

*Contain isolation diodes for multiplexing **Servo driven, hermetically sealed

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CIRCLE 1 ON READER-SERVICE CARD

LEWIS SELECTOR SWITCHES

for RESISTANCE THERMOMETERS

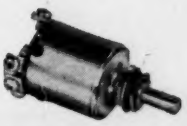
for THERMOCOUPLE THERMOMETERS

THE 9S SERIES / *The Space Savers*

Small, sturdy, steel cased switches, 1¼ inches in diameter, 2$^{9}/_{32}$ inches total shaft length, one-hole mounting with ½ inch-32 NS-2A threaded bushing. Designed especially for connecting two or more resistance bulbs to one instrument.

Part No.	Description
9S5	Single pole, four positions (with knob)
9S5B	Single pole, four positions
9S5E	Single pole, five positions
9S10	Double pole, double throw

All make before break, the instrument connected is never subjected to an open circuit during the switching operation.



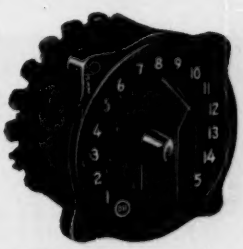
1¼ INCH SIZE

EACH SWITCH HAS "OFF" POSITION PLUS NUMBER OF POINTS LISTED.

Points	Size	Switch Part Numbers: Thermocouple Type	Switch Part Numbers: 3 Wire Resistance-Thermometer Type
2	2"	11S2	36SR2
3	2"	11S3	36SR3
4	2"	11S4	36SR4
5	3"	10S5	37SR5
6	3"	10S6	37SR6
8	3"	10S8	37SR8
9	3"	10S9	37SR9
10	3"	10S10	37SR10
12	3"	10S12	37SR12
16	3"	10S16	37SR16
18	3"	10S18	37SR18
20	3"	10S20	37SR20
24	4"	27S24B2	38SR24
28	4"	27S28B4	38SR28
40	4"	38S2C	

(No. 38S2C is made with soldering-lug terminals)

2 INCH SIZE



3 INCH SIZE

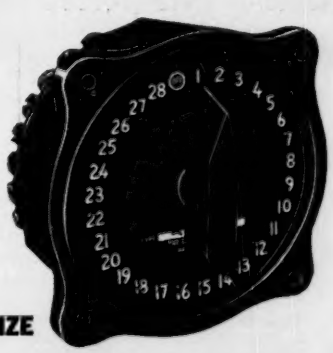
SPECIAL SWITCHES 37S6C2, Four "4-point and OFF" thermocouple switches combined in one 3" case.

The 44S Series, 2$^{9}/_{32}$ inches in diameter, shaft 2¼ inches, approx. One-hole mounting with ½ inch-32 NS-2A threaded bushing.

Part No.	Description
44S4	Six pole, double throw
44S7B	Double pole, four position
44S7B2	Double pole, double throw

For use with resistance thermometer, contacts make before break.

DESIGNED FOR TEST WORK AS WELL AS FOR PERMANENT INSTALLATIONS. LEWIS SELECTOR SWITCHES ARE CONSTRUCTED WITH STURDY CONTACTS OF LOW RESISTANCE AND POSITIVE DETENT. THESE SWITCHES ARE SPLASHPROOF, DUSTPROOF AND ARE BUILT TO GIVE YEARS OF SERVICE.



4 INCH SIZE

THE LEWIS ENGINEERING CO.

Specialists in Electrical Temperature Measurements

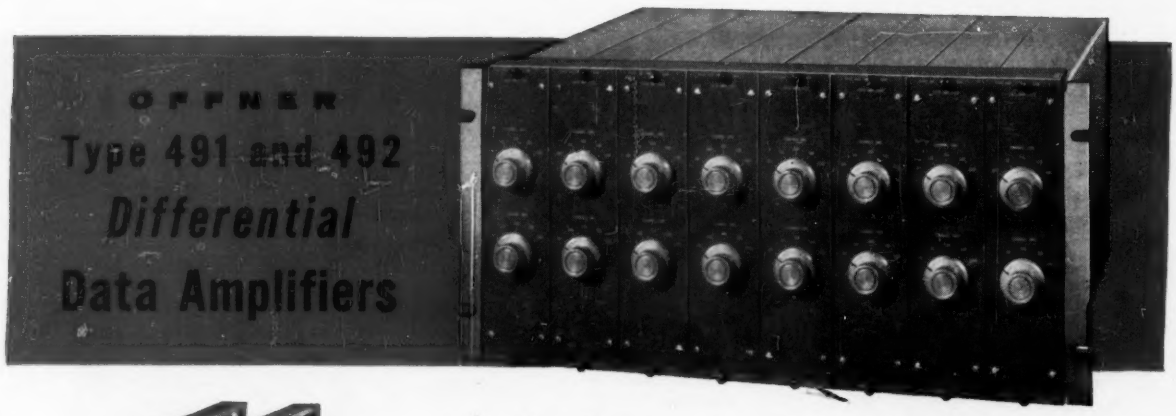
NAUGATUCK, CONNECTICUT

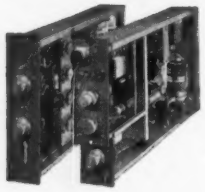
CIRCLE 2 ON READER-SERVICE CARD

Two completely new, transistorized, differential Data Amplifiers, Types 491 and 492, by Offner Electronics Inc. Their high precision makes possible an accuracy and simplification of data reduction previously impossible.

1/100% accuracy
1/100% gain stability
1/100% linearity

Sixteen channels of data reduction (Type 492) requires only 8¾" of rack space. Power supply occupies only 5¼". The combination of accuracy, stability, fast response, and size is unmatched.





Type 492 Amplifier (left) provides 2 channels of precision amplification per unit. The Type 491 (right) is a single channel unit, with input coupler for added versatility.

featuring

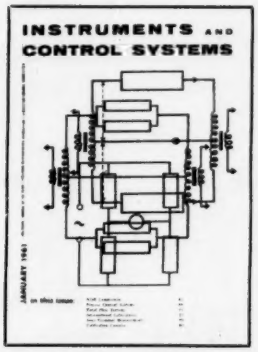
1/100% accuracy

1/100% gain stability—for 1,000 hours at normal ambients
1/100% linearity—for full output
All-transistor construction
1/400th second response—to step input
Very low output impedance—less than 0.1 ohm
Infinite rejection—of common d-c signals
120db rejection—at 60 cps
16 channels in 8¾ inches of rack space (Type 492)
Versatile input couplers (Type 491)

OFFNER ELECTRONICS INC.
3910 River Road, Schiller Park, Ill. (Suburb of Chicago)

CIRCLE 14 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS



Transformer ratio-arm bridge (page 102) is one article in this month's subject of major emphasis —electrical measurements. This continues our two-year series on this subject. We also welcome the PRECISION MEASUREMENTS ASSOCIATION with this issue (page 85).

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INSTRUMENTS AND CONTROL SYSTEMS

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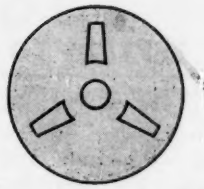
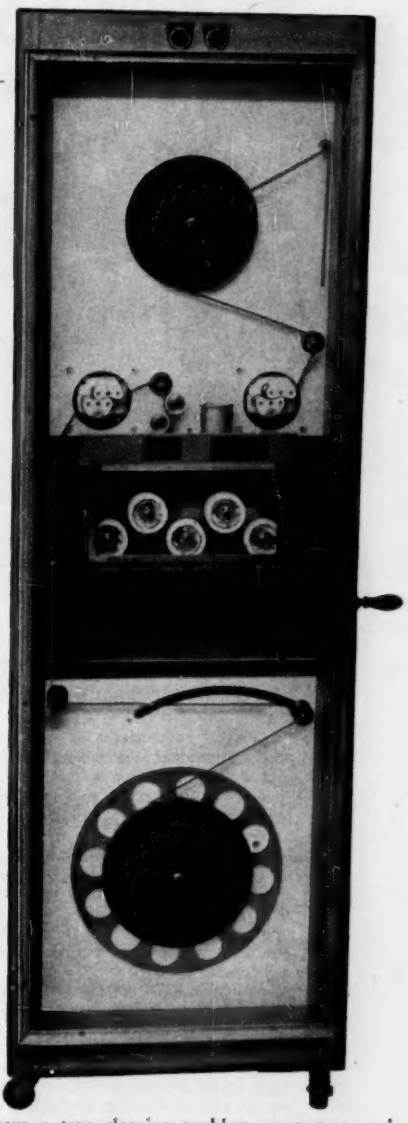


Clean your magnetic tape

- *Rapidly*
- *Safely*
- *Automatically*

with CMC's NEW SOLVENT CLEANER



Information stored on tape is not disturbed in any way. No drop-out, no distortion, no tape stretch. Head wear and damage is reduced by eliminating abrasive particles from tape surfaces.

All you have to do is put the tape in place and fill the solvent tank. The new CMC Model A-7070 cleaner does the rest automatically and speedily—with all scrubbing action taking place below the solvent level. It effectively cleans magnetic tape up to 2" in width at rates to 300 feet per minute with complete safety. Cleaning is accomplished by counter-rotating velvet covered scrubbing rollers, effectively removing ferrous oxide particles, dirt, lint, oil, fingerprints and wax.

COMPLETELY SELF-CONTAINED. *No vacuum pump or outside sources of air are required.*

FLUID CUSHION PROTECTS TAPE. *The fluid solvent forms a barrier between the scrubbing roller and tape to prevent scratches and abrasions. Only velvet fibres lightly touch the film.*

SPEED CONTROL. *Operate at any speed from 0 to 300 feet per minute with adjustable speed control. Automatic shut-off leaves unit threaded for continuous operation.*

COMPLETELY SAFE. *Uses only non-inflammable, non-explosive solvents. Fumes controlled. Automatic shut-off in case of defective splices.*

AUTOMATIC REWIND. *Makes necessary torque adjustment as reel size increases.*

LOW COST OPERATION. *Solvents are continuously filtered and reclaimed; waste held to minimum. One pint of solvent cleans 3,000 feet of 1" tape.*

PRICE. *Model A-7070 $5,500 f.o.b. Sylmar, California.*

If you have a tape cleaning problem, contact us and arrange to have a sample tape cleaned for your inspection. Contact your local CMC representative for complete technical details, or write for 4-page brochure, please address Dept. 551.

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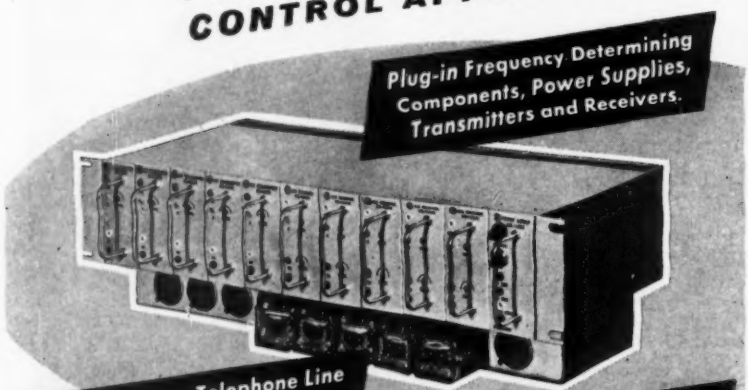
CIRCLE 4 ON READER-SERVICE CARD

REMOTE INSTRUMENTATION & CONTROL

Newest RFL Transistorized Series 2056

AM and FS Tones

for TELEMETERING and CONTROL APPLICATIONS


Plug-in Frequency Determining Components, Power Supplies, Transmitters and Receivers.
For Microwave, Telephone Line and Voice Carrier Applications.
Featuring Latest Design Based on Years of Field Experience.

Modern Design . . .
10 Transmitters or Receivers
and Power Supply in One Single Frame.

The 2056 Series of Audio tones features modern design utilizing plug-in card construction and provides equipment at a very minimum in cost with a maximum number of channels in a given space. For example, 10 AM transmitters or receivers and a common power supply are mounted in a single 3½ x 19" frame. Each channel is conveniently terminated with a terminal strip at the rear of the frame. Output relays are mounted on a bracket attached underneath the main chassis frame, each relay being located directly under its respective channel.

The channel frequency determining components are also of the plug-in type and are mounted directly on the channel plug-in assembly in AM units, and adjacent to plug-in assemblies on FS units. This type of design, of course, keeps spare parts requirements to a minimum, since all plug-in cards are common to all frequencies.

The 2056 Series of AM tones were designed to meet low speed tone signalling and control requirements when low noise lines and inherently low noise communication circuits as provided by microwave and voice carrier equipments are available for transmission.

The 2056 Series of FS tones are used when ultimate reliability and high speed keying is required. They can be used in circuits which are inherently noisy and which are subject to fading conditions.

The FS tones are available with either TWO or THREE frequency outputs. The former being employed in normal signalling and control circuits, whereas the latter is used in two-function single channel applications such as RAISE-OFF-LOWER, FORWARD-OFF-REVERSE.

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Boonton, New Jersey, U.S.A.

CIRCLE 5 ON READER-SERVICE CARD

LETTERS TO THE EDITOR

Editor I&CS:

We note on pages 1280 and 1281 of your August 1960 edition, a list of variables which, according to your readers, could not satisfactorily be measured.

Since our company deals specifically with instruments for the measurement of gas and liquid flows, we were wondering whether it would be possible for us to get a listing of the companies having these flow problems, as a good portion of the variable flows you list would present no problem for our Rotameters.

Jack Dannenberg
Brooks Instrument Co., Inc.
Lansdale, Penna.

This letter will inform the men with the problems.

Editor, I&CS:

I have read several recent copies of your magazine and feel that your reporting in this field is excellent. Coverage in the field of instrumentation and control systems is certainly not sufficient in other magazines. Your publication fills an otherwise serious gap.

Leonard C. Stearns
Data Evaluation Group
Space Technology Laboratories
Los Angeles, California

Editor, I&CS:

I have been receiving notices that my subscription to your publication was running out. I paid no attention since my records show that I mailed you my check.

I am enclosing a second check for $4.00 to cover the year 1961. I certainly do not want to miss any copies of your fine publication.

Albert E. Miller
Petroleum Consultant
Westfield, N. J.

Editor, I&CS:

Enclosed please find a check for subscription to *Instruments and Control Systems*, plus the *Handbook of Electrical Measurements*. I am beginning to study instrumentation and your magazine was recommended as the best in the trade.

Emanuel E. Echert
Ottsville, Penna.

Editor, I&CS:

It's been a long time since you heard from me, although you may have seen our recent ad in your new *BUYERS GUIDE*, which I think is the most logical place for any ad in the instrumentation field.

Enclosed is our most recent report on *STRAIN GAGE READINGS*, in which you may be interested since after all you were in on the birth of our little journal almost three years ago.

We're filling a very special need in the strain-gage field.

Strain Gage Readings,
Peter Stein, Editor
5602 E. Monte Rosa
Phoenix, Arizona

Editor, I&CS:

You are continuing to do what I think is an outstanding editorial job in the field.

W. W. Winters
Automatic Timing & Controls
King of Prussia, Pa.

Editor I&CS:

There have been times in the past when I have wanted to compliment you, but I never took the time to express my reasons for commendation. It amounts to the following formula: *New Idea + Excellent Editor = Progress.*

All Editors do not use this equation in particular cases because (1) *the idea or material is not understood* so it is discarded. This may be fatal to progress because the idea may be lost due to lack of exposure and, if the originator lacks confidence and advertising funds, the idea dies. (2) *The idea is introduced poorly* and hence the Editor may not appreciate its true value; as a result, it too is discarded. (3) The idea conflicts with present practice or convention, or a large advertising account; consequently the Editor discards it because of lack of courage or vision.

From my experience with I/CS you have knowledge, appreciation, courage, and vision which has contributed greatly to progress in our field.

I am not a sentimental slob but I appreciate talent and character when I see it.

T. Gizeski
Chicago, Ill.

We love sentimental slobs. Editors would have more courage if they knew their readers can sense their integrity.

hays

RAMBLINGS ON INSTRUMENTATION

My Pilgrimage to Poopley

POOPLEY-ON-SLOUGH, NUTTINGSHIRE, U.K.

The sight from my window as I write, dear colleagues, is one to warm the cockles of any instrument-oriented heart. As you have already guessed from the dateline, yours truly is at one of the great shrines of Science, famous Poopley, where the first British Thermal Unit made its appearance some 178 years ago.

The tiny village is little changed except today, on the exact site where the Event took place, stands a modest monument built from contributions of BTU buffs the world over.

When the tram pulled into Poopley yesterday my first act was to ask a rustic villager where the Monument was. A proud light kindled in his eyes.

"Aye, mon, it'd beein' oe'r there'n mought 'nuff 'erg," he told me, tugging his forelock. (Learned later the chap was game-keeper at the old Chatterley place.) I hurried off to find someone who spoke English. Eventually I found the Monument.

There, flanked by fluted columns, was the Flame, the undying flame that heats the Calibrator, producing the standard British Thermal Units that are distributed by the thousands throughout the Free World. Before it, a smallish man with a walrus mustache was peering fixedly. Col. Gideon W. Belcher himself, Keeper of the Flame and walking encyclopedia of BTU lore!

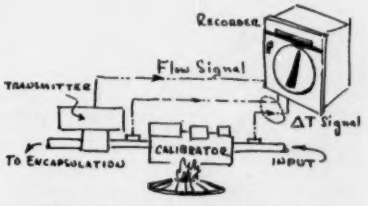
Reverently, the Colonel displayed the key to the entire operation, a Hays BTU Meter chronicling with rhythmic monotony the beautiful precision of the thermal units being generated in the Calibrator. The Colonel removed his Homburg and I followed suit. Bareheaded, we stood in the flickering light, watching the lovely, fluid movements of the recorder pen, its graceful Palmer-method scallops mirroring BTUs at the point of sheerest perfection. It was a moment for posterity.

The Colonel blew his nose. "Wizard device, that," he rumbled. "Linear record of flow, Delta T and BTU all on the same chart!"

"Plus integration of BTU", I breathed.

"Quite. Remote flow transmitter. Resistance bulbs. Good show! Can't afford less on this job, you know. If the BTU ever went to pot I shudder to think!"

Later I listened raptly as the Colonel told of his harrowing experiences as Keeper of the Flame; such as the night a gaggle of Scottish Nationalists made an abortive attempt to blow it out . . . that touchy time when a Russian scientist declared the superiority of Iron Curtain-type thermals. (The Colonel caned the bounder thoroughly and the lights burned late on Downing Street *that* night, I tell you.)



Sketched from life at Poopley, shrine of the British Thermal Unit.

Well, twilight is descending on dear Poopley, chaps, and I haven't even touched on the preparations going forward for the 178th Anniversary Celebration. May I only say you will be proud when you see the newsreels.

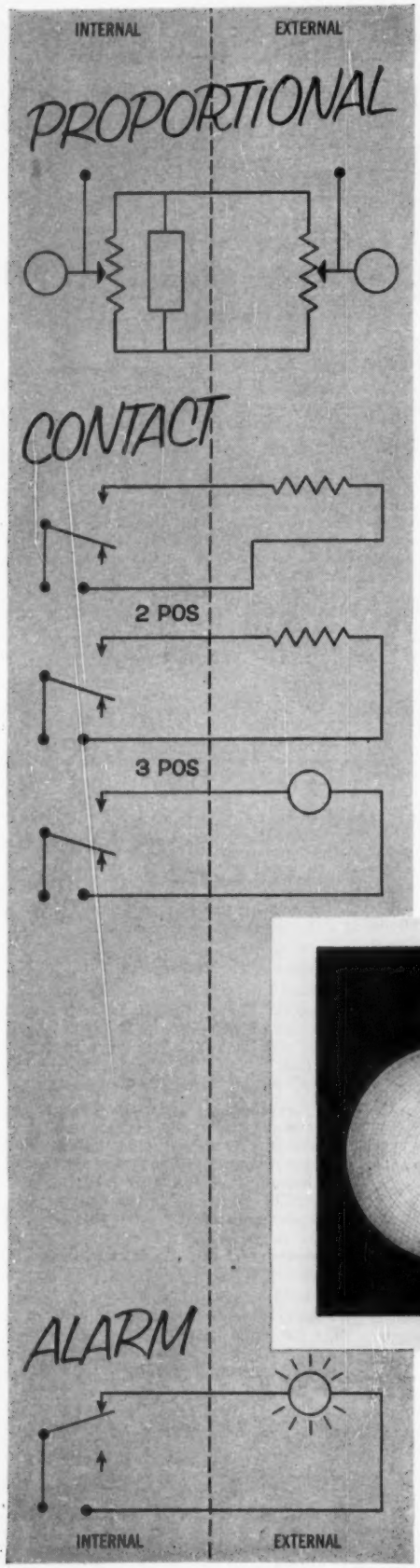
Finances, unfortunately, are a thorny problem. I am sure none of you would want the Celebration to be less than a rouser. Need I remind you that, with each purchase of a Hays single-case BTU Meter, we make a substantial contribution in the purchaser's name to the Committee for Everlasting Maintenance of the British Thermal Unit.

So, dear colleagues, start the New Year selflessly. Buy a Hays BTU Meter, for yourself and a friend. Your generosity will be gratefully acknowledged by Col. Belcher himself.

R. A. Sprague
President

THE HAYS CORPORATION • MICHIGAN CITY, INDIANA

CIRCLE 6 ON READER-SERVICE CARD



ANNOUNCING . . . WESTON RECORDER-CONTROLLER WITH ECONOMY NEVER BEFORE AVAILABLE!

New Weston Recorder-Controller with electrical control is available with following control modes:

- PROPORTIONAL CONTROL covering a range of 1 to 100% proportional band with manual reset
- CONTACT SWITCHING for two and three position control and adjustable differential gap
- ALARM SIGNALING where attention of personnel is required

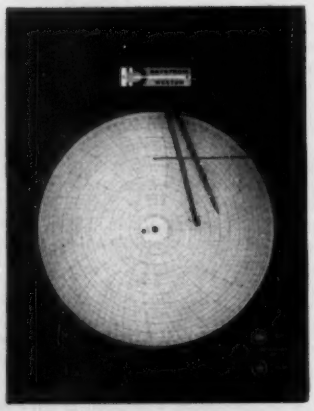
For sheer economy, the new instrument is unexcelled. The proportional controller combines the simplicity of mechanical instruments with electrical control advantages previously limited to potentiometric instruments . . . *at half the price!* Initial cost and maintenance are much lower than with pneumatic type controllers.

You can use the proportional controller with a variety of liquid- and mercury-filled temperature systems. Contact and alarm controllers operate with all types of temperature and pressure actuations.

The electrical portion of the instrument is based on solid state devices and printed circuits for utmost reliability. No external control relays needed! Control units may be removed without interfering with recording activities. Contact and alarm controllers are designed to resist vibration. Temperature ranges are from —100F to +1000F. Pressure ranges for the on-off and alarm versions are from 30" vacuum to 10,000 psi.

Contact your Weston representative for detailed information, or write for technical information on the Weston Model 7813. Daystrom, Incorporated, Weston Instruments Division, Newark 12, New Jersey.

International Sales Division, 100 Empire St., Newark 12, N. J.
In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ontario.



Recorder-Controller uses a 12" chart; has a 4.75" pen travel, rugged bridge-type pen arm suspension. Large bucket pen standard.

Supply: 115 volts, 50 or 60 cycle for instrument; 115 or 230 volts, 50-60 cycle for external control motor.

Model 7813 Proportional Controller

Available: With any mercury or liquid filled thermal system.

Contact Controller

Available: Any combination of two control units (2 or 3 position or differential gap) with all temperature and pressure actuations.

Alarm Contacts

Available: 1, 2 or 3 alarm points for most temperature and pressure recorders and controllers.

DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION
Reliability by Design

CIRCLE 7 ON READER-SERVICE CARD

LETTERS TO THE EDITOR

Editor, I&CS:

Please accept our sincerest thanks for the wonderful presentation of the article "Manual Timing Techniques." It is really a beautiful job.

We already have ordered a reprint of 10,000. Heuer/Switzerland intends to have the article translated in several languages for advertising purposes by their foreign Heuer distributors.

Gaston G. Wiley
Heuer Timer Corporation
New York, N. Y.

Editor, I&CS:

I was asked what magazine I think is the best all-round instrument magazine. Having been a subscriber to *Instruments* for 12 years, that was an easy one to answer.

W. E. Bostwick
Lawrence Radiation Lab.
Livermore, Calif.

Editor, I&A:

Do you expect to obtain superior men by screaming shortage? I realize that, having avoided the truth this long, it would be hard to change, but how can you really claim a "shortage" when "engineers" do detail work at long rows of benches or desks?

Of course it would make the employment offices and the offices and the colleges unhappy if you told the truth because they want large numbers. But the truth remains that there are so many "engineers" now that the measure of success is the ability to fight up through the mob, not engineering, or executive ability.

The men that could be the engineers and scientists of which you dream are also the ones who can do well in other fields. Now, after some experience, they go into sales or small industry. Their abilities are not applied to the great problems of our times, but to the economically profitable little things that will earn them a respectable living.

John M. Graham, P. E.
Graham & Associates
Bellwood, Ill.

See the editorial on page 61

NOW...AN INDUSTRY FIRST FROM FAIRCHILD

A REVOLUTIONARY PRESSURE TRANSDUCER WITH 5V. D-C OUTPUT

TRIPLE S-G

SOLID-STATE STRAIN GAUGE TRANSDUCER

OTHERS MAY HAVE PROMISED IT... STILL OTHERS MIGHT HAVE HINTED THEY'RE ON THE VERGE OF GETTING IT... BUT ONLY FAIRCHILD HAS IT!...THE INDUSTRY'S FIRST 3S-G

The Fairchild 3S-G combines the best overall characteristics of both strain gauge and pot-type transducers, has none of their inadequacies. It has a semiconductor strain-gauge sensor. It possesses extraordinary accuracy and environmental capabilities. It produces a 5-volt d-c output signal that eliminates the need for impedance-matching or signal amplification. In its utter simplicity (only two mechanically-functioning parts) it is extremely reliable. It also incorporates a resistive calibration device.

The Fairchild 3S-G is responsive to both static and high-frequency dynamic pressures. It is fully compatible with existing military ground telemetry and industrial systems. It is competitively priced, measures all media and is insensitive to case distortions.

The Fairchild 3S-G is only 3" long, 1⅛" diam., and weighs only 5 ounces. It meets and exceeds MIL-E-5272B. Pressure ranges from 0-100 to 0-10,000 psig full scale now available, below 100 psig will be available soon. Better than ±0.1% linearity and 0.1% hysteresis over temperature range of −65 to +250°F. Both zero and full range sensitivity change less than 0.5% over any 100°F excursion within the rated temp. range. It has infinite resolution.

Fairchild components... built and tested beyond the specs for Reliability in Performance.

FAIRCHILD CONTROLS CORPORATION

225 Park Ave., Hicksville, L. I., N. Y. • 6111 E. Washington Blvd., Los Angeles, Cal.
A Subsidiary of Fairchild Camera and Instrument Corporation

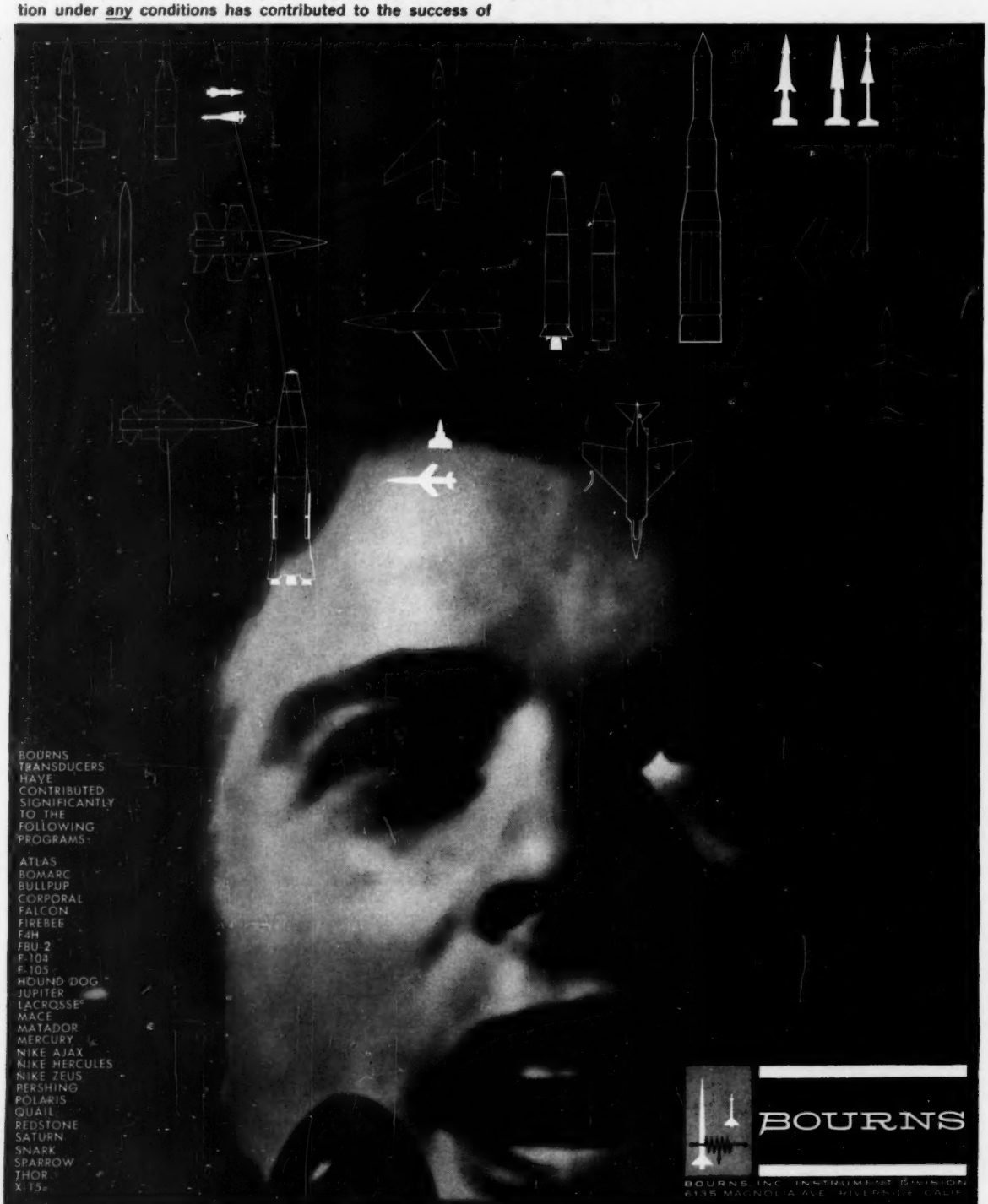
TRANSDUCERS
RATE GYROS
POTENTIOMETERS
ACCELEROMETERS

CIRCLE 8 ON READER-SERVICE CARD

Reliability a Reality With Bourns Transducers

NUMBER 9—INSTRUMENT SERIES

In program after program... firing after firing... Bourns transducers are surviving the most brutal environmental punishment ever inflicted on sensitive instruments. Their ability to provide precise indication of position, pressure or acceleration under any conditions has contributed to the success of the most important missile and aircraft programs of our time. For engineering that combines design skill with success... promise with performance... contact Bourns, the pioneer in precision transducers.



Pioneers in transducers for position, pressure and acceleration. Exclusive manufacturers of Trimpot®, Trimit® and E-Z-Trim®.

CIRCLE 9 ON READER-SERVICE CARD

HOKE **Flow Sheet** 3

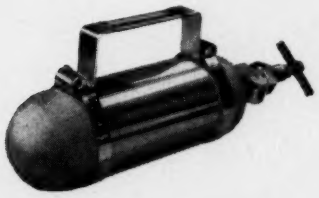
HOKE REPORTS ON FLUID CONTROL

WE'VE TOSSED A NEW BALL INTO AN OLD GAME

Do You Have A Bomb In Your Lab?

In the process industry, sampling cylinders are occasionally referred to as bombs. In recent months, this misnomer has been, unhappily, pretty close to the truth. Some military surplus, low carbon steel, two-piece cylinders have found their way into industry and have been used beyond their rather limited capabilities. Unfortunately, several serious accidents have spotlighted this use as a very real safety problem.

Since sampling is such a serious business, we have perfected, for maximum safety, a seamless, one-piece cylinder. This unabashed declaration of excellence has sound



basis in fact – the entire cylinder is formed from a single piece of seamless type 304 stainless steel tube. To quell the qualms of process men, sample contamination is practically nonexistent, and the cylinder resists destruction from most corrosives.

As a further safety guarantee, all standard sampling cylinders are fabricated to meet ICC and other safety regulations. Standard cylinders are available at pressures to 1800 psi (10 ml. to 1 gallon), but higher pressure cylinders can be had on special order.

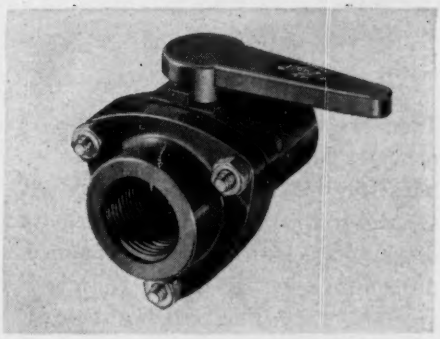
If you'd like additional information on Hoke cylinders, plus a detailed paper on the various methods of collecting samples from process lines, drop us a line. We'll also include details on special cylinder valves, outage tubes and other cylinder accessories.

The technique of molding polyvinyl chloride into ball valve parts is old hat. Even the unplasticized compounds of type I PVC have been kicked around for a while (with minor successes). But until now, no one has booted the ball for a goal.

Perseverance, determination, and the pursuit of economic reward have prompted us to offer a line of ball valves molded of the toughest grade of type I, unplasticized PVC. There are no foreign agents to contribute to a corrosive demise, even in most caustic services. It even meets the proposed new ASTM specification and has a tensile strength of 8500 psi. Those who have had PVC piping problems will profit from the new molding process that gives these Hokes dimensional stability and very high impact strength. Sensitive systems, human and otherwise, are safe from contamination – they're absolutely non-toxic. We've set 140°F. as the operating temperature limit, but occasional excursions to 160°F. won't do any harm.

All standard models are supplied with a concentric hole drilled thru the ball. They can be heat welded, or solvent bonded right in the line. Piping hook-up is even simplified by their coupling-like assembly. Your assistant can fit each half of the valve to a pipe end, then reassemble the valve without having to turn the pipe. Pressures to 125 psi are duck soup for these valves.

A maintenance man's delight, they can be cleaned and have their seats changed without leaving the pipe. Their light weight makes them ideal for use on long, unsupported spans of pipe.



Size-wise, we're offering them in ½, ¾, 1, 1½, 2, and 3 inch sizes, all NPT female connections.

You will command the eternal admiration of your colleagues when you install these valves. Be the first to show your rightful status by ordering a shiny new Hoke polyvinyl chloride ball valve. If pride of ownership hasn't motivated you at this point, the mere fact that you are behind the scientific times should move you to find out more.

It isn't necessary to tell us why you want the additional information. Just check the coupon below. We'll forward the facts in a plain, brown envelope.

FREE! A STEADY FLOW OF FACTS!

Further flow features, and interesting technical topics are carefully covered in Hoke's technical publication, the FLOW SHEET. It's free, but worth millions! To get the full benefit of our engineering and editorial efforts six times a year, mark your "X" in the proper box.

Hoke's Performance Guarantee — *Every Valve Leak-Tested!*

HOKE, INCORPORATED
31 Piermont Road, Cresskill, N. J.

Send me complete information on the Hoke products checked below:

- ☐ PVC Ball Valves
- ☐ Sampling Cylinders
- ☐ Flow Sheet
- ☐ FREE Corrosion Slide Rule
- ☐ Complete Catalog GC959

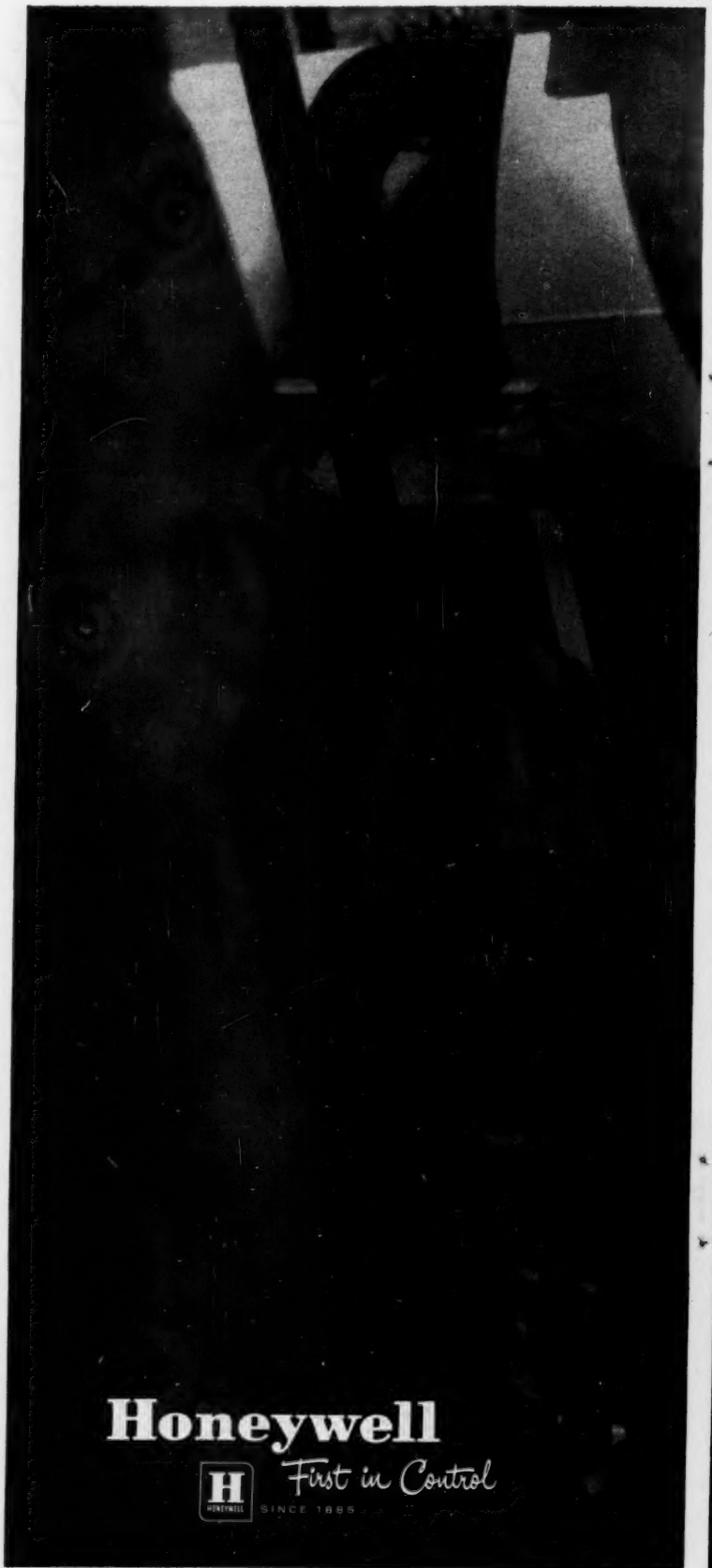
NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ STATE _____

CIRCLE 10 ON READER-SERVICE CARD



The Honeywell Control Valve (foreground) regulates flow of Bunker C fuel oil burner in a chemical process drying system. In the background, a Honeywell diaphragm actuator operates a damper for control of hot air return. Nothing spectacular going on here, but the results of the entire process could well depend on these valves.

The final results—the payoff of the process—are dependent not just on how well these valves are made, not just on their capacity or sensitivity, but on *all* of these things combined . . . plus the process control knowledge that first put them to work, and the know-how that keeps them on the job.

Here, as in all Honeywell Control Valve applications, *every* aspect of valve performance has been considered in relation to the overall control system. It is this "whole picture" approach that sets Honeywell Control Valves apart, and rewards you with better processing.

Write today for your copy of our checklist, "25 Ways to Be Right" . . . in selecting control valves.

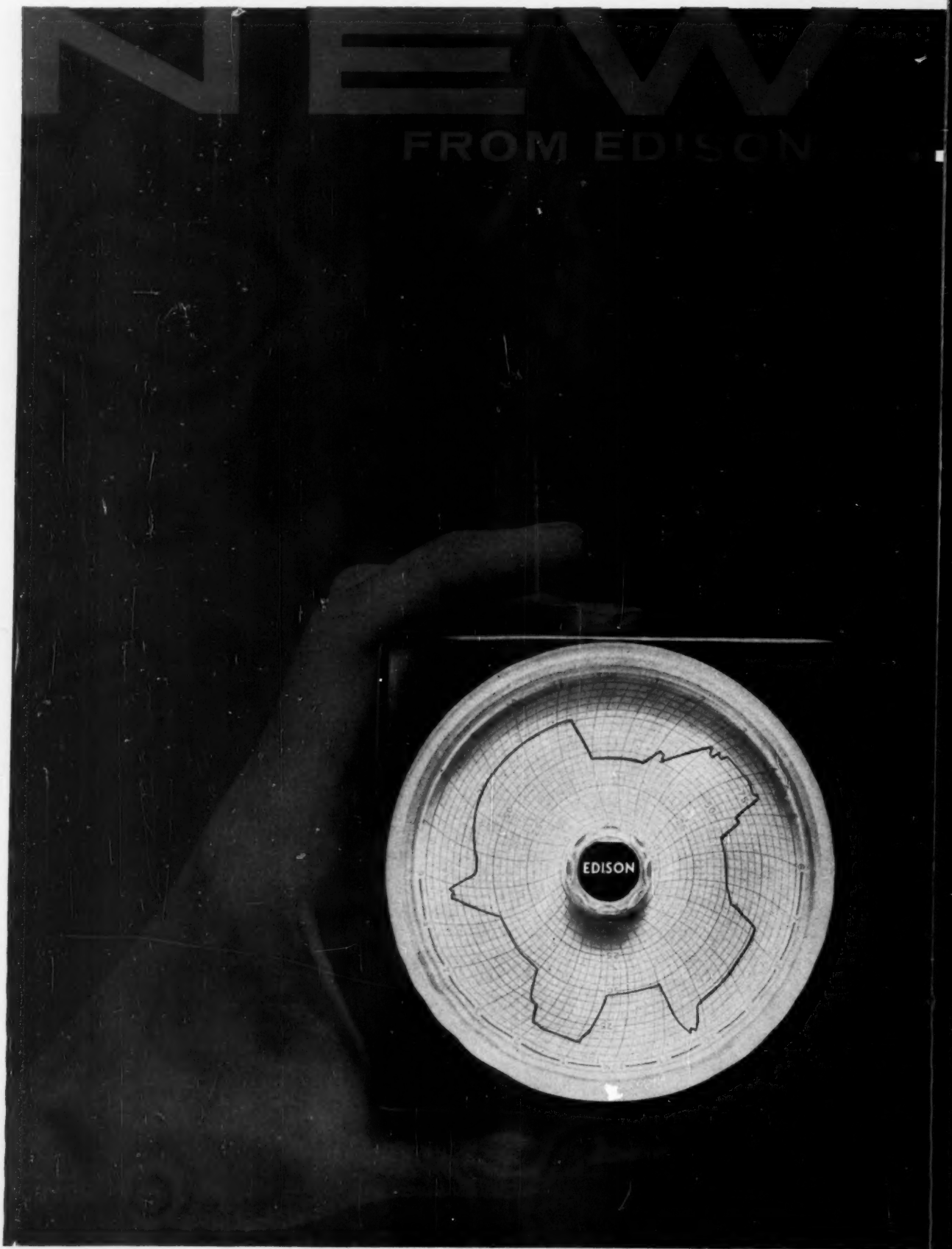
MINNEAPOLIS-HONEYWELL, Fort Washington, Pa.

HONEYWELL INTERNATIONAL
Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

Photographed at Davison Chemical Company, a division of W. R. Grace & Company.

CIRCLE 11 ON READER-SERVICE CARD

CIRCLE 11 ON READER-SERVICE CARD



CIRCLE 12 ON READER-SERVICE CARD

....OMNICORDER

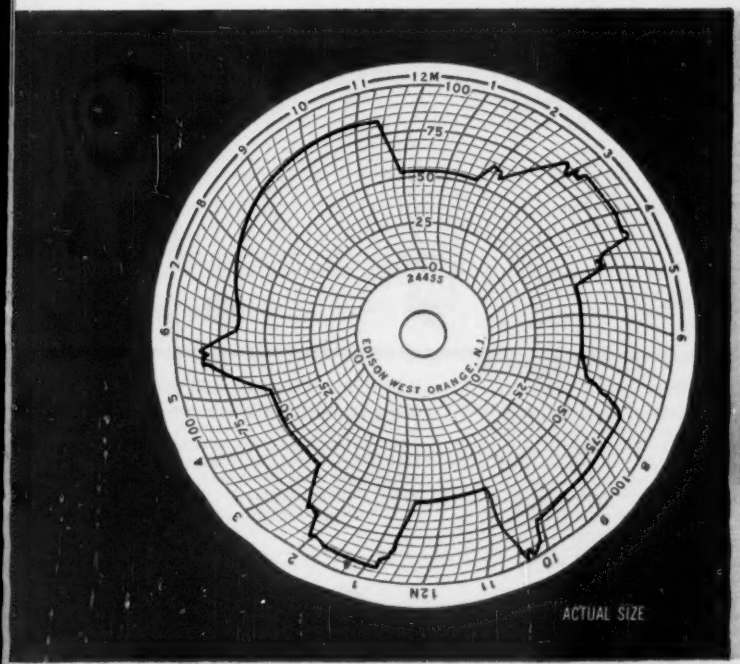
A PRECISE MINIATURE INKLESS RECORDER

■ INEXPENSIVE ■ REPLACES METERS OR INDICATORS ■ PANEL OR BULKHEAD MOUNTED
■ BUILT-IN VARIABLE CHART SPEED ■ JUST 3¾" X 3¾" X 3" ■ RECORDS ANY VARIABLE

Now you can take advantage of a new, economical means of recording any variable that can be converted to an electrical signal. Thanks to Omnicorder, you need no longer rely on meters or indicators, even where cost factors or space restrictions would ordinarily dictate the use of these instruments.

Measuring just 3¾" x 3¾" x 3", Edison's Omnicorder, a unique circular chart recorder, is so compact that nine units occupy just one square foot of space. Thoroughly legible, yet requiring no ink, pen or ribbon, Omnicorder is equipped with a simple three-speed chart adjustment. It provides a choice of these sequences: one hour, seven hours and thirty hours per revolution—or one day, seven days and thirty days per revolution.

Omnicorder's simple, inexpensive construction assures dependable operation and a long, maintenance-free life. Four types of meter movements are available to measure a wide range of AC and DC electrical quantities, ranging from thermocouple outputs to currents as high as 600 amperes with accessory current transformers. No amplification is ever required, even for signals as low as 10 microamps.



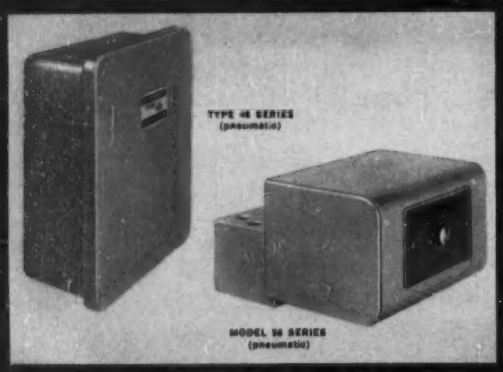
Stylus operates through this slot. The measuring system is sealed off from any careless tampering.
HOUR
7 HOURS
30 HOURS
EDISON
RECORDER
ZERO
Zero Set Screw: Adjustment is made when measuring system is not printing and when the circuit to be recorded is disconnected.

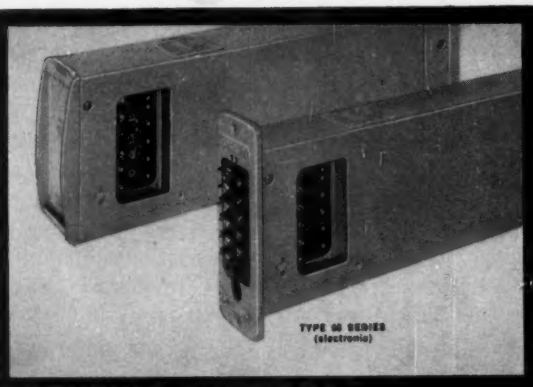
For complete information on this rugged, maintenance-free Omnicorder, write for Catalog 3057.

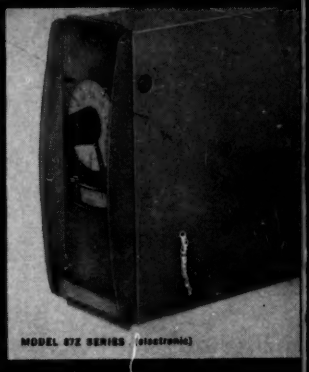
Thomas A. Edison Industries
INSTRUMENT DIVISION
41 LAKESIDE AVENUE, WEST ORANGE, N. J.

CIRCLE 12 ON READER-SERVICE CARD

new low-cost Foxboro simplify automation

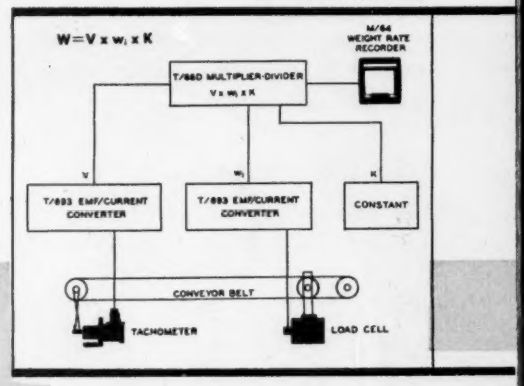






FOXBORO ANALOG COMPUTING STATIONS

▶ TYPICAL



WEIGHT RATE COMPUTATION

Gives operator continuous recording of actual weight of materials being conveyed by belt. For example, T/66D Multiplier-Divider calculates actual weight-rate from load cell and belt speed measurements.

CIRCLE 13 ON READER-SERVICE CARD

Analog Computing Systems of process mathematics

both pneumatic and electronic units available

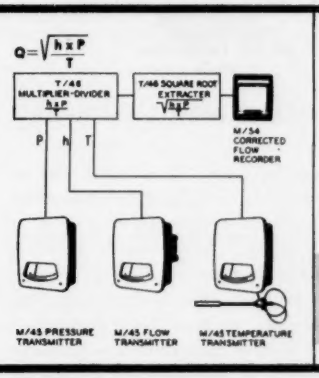
Analog computing systems have been known and used for years. Yet their potential for increasing process efficiency has hardly been scratched.

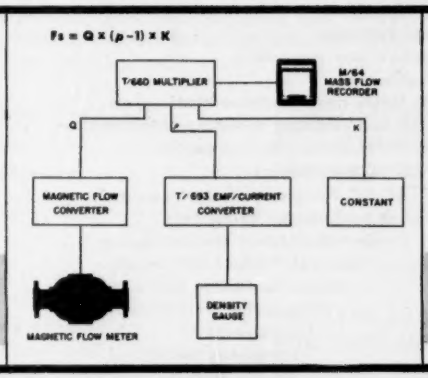
Just look what they can do! Continuous calculation of all the arithmetic functions: addition, subtraction, multiplication, division, square root extraction — in any combination. And all done automatically by a single packaged system.

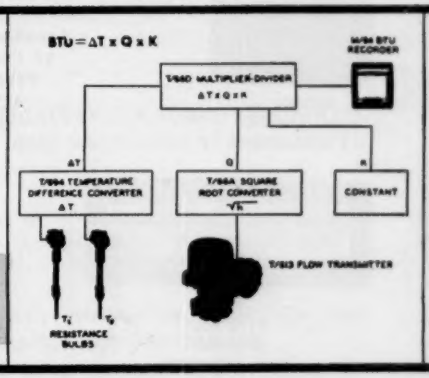
And look how it simplifies the operator's job. Instantaneous calculation . . . with records to prove it. No slide rules, no interpolation, no planimeters — and most important — no mistakes.

Because Foxboro Analog Computer Systems are relatively low-cost ($2500-5000 average) you can "spot" them about your plant for maximum efficiency. Or, they can be grouped together at a central location to solve more complicated equations. Pneumatic and electronic systems available.

CALCULATIONS MADE WITH FOXBORO ANALOG COMPUTING SYSTEMS







GAS FLOW COMPUTATION

In common use in the Gas Industry to compensate gas flow readings for changes in line temperature and static pressure. In the pneumatic system shown here, the Foxboro T/46 Multiplier-Divider and the Square Root Extractor allow operator to read corrected flow directly.

MASS FLOW COMPUTATION

Calculates dry weight of a slurry flowing through a pipeline. In this electronic system, flow rate and density measurement are multiplied together with a Foxboro T/66D-1 Multiplier. Operator can then read flow directly in Dry-Tons-Per-Minute.

BTU COMPUTATION

Determines actual amount of heat being introduced to, or removed from, a process. Electronic system shown uses a Foxboro T/66D Multiplier-Divider to produce a signal equal to product of flow and temperature difference. Operator reads directly in Btu's.

WHAT CALCULATIONS WOULD YOU LIKE TO AUTOMATE? ➔

FOXBORO

REG. U. S. PAT. OFF.

CIRCLE 13 ON READER-SERVICE CARD

The Foxboro Company, 461 Norfolk St.
Foxboro, Mass.

I have a process computation I should like to automate. Can a Foxboro Analog Computing System do it for me?

My process is.....

I want to compute.....

.....

Name.....

Position.....

Company.....

Address.....

City.....**State**.....

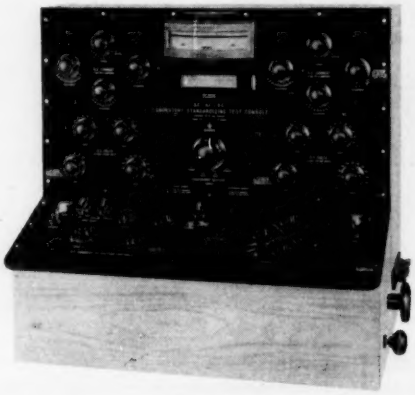
Welcome PMA

Sensitive Research Instrument Corporation, manufacturers and designers of electrical instruments since 1927, welcomes the Precision Measurements Association to this issue of I & C S. The Journal of the PMA, with its news of accomplishments and developments in the field of high accuracy measurements, is certain to be a most welcome addition to the monthly reading of standards engineers everywhere. The beneficial influence of the PMA as a National Organization is eagerly looked forward to by all who appreciate the importance of standardization as a means to improved product performance and reliability.

The entire facilities of Sensitive Research and those of its associate, Guildline Instruments, Ltd., are devoted to the manufacture of precision electrical measuring standards. Electrical indicating instruments, test consoles, potentiometers and related equipment as listed below are used in major calibration centers throughout the world.

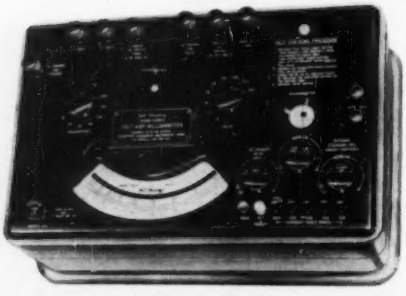
AC-DC Calibration Consoles
DC Measuring Potentiometers
AC Measuring Potentiometers
Volt Ratio Boxes
Galvanometers
4 Terminal Standard Resistors and Shunts
Constant Temperature Standard Cell
Enclosures
Standard Cells
Direct Reading Thermometer Bridge
Platinum Resistance Thermometers
Cable Fault Finder
Smith Bridge
Standard Inductors
Photocell Amplifier
Frequency Selective Amplifier
Low-Thermal Choppers
Low-Thermal Switches
RF Voltmeters and Ammeters
VTVM Calibrator
AC-DC Single and Polyphase Wattmeters
AC-DC Self-checking Volt-Amp-Milliammeters
AC-DC Electrostatic Voltmeters
AC-DC Polyrangers
AC-DC Thermocouple Instruments
Potentiometer Voltmeters
Zero Resistance Microammeters
Current Product Instruments
Magnetic Testing Instruments
Differential Galvanometers
Incremeters
Frequency Meters
Ratio Meters
Form Factor and Power Factor Meters
DC Voltage Standard
Low Distortion AC Power Supply
Scale Drawing Machine
AC-DC Panel Instruments
AC-DC Portable Voltmeters and Ammeters
Vacuum Thermocouples

MODEL N
AC and DC
Portables



MODEL LTC
AC-DC Calibration
Console

TYPE EW
Edgewise
Panel Instrument



MODEL THACH
Self-Checking
AC-DC Volt-Amp-Milliammeter

VISIT US AT N.Y. IRE
BOOTHS 3409 - 3411

SENSITIVE RESEARCH INSTRUMENT CORPORATION

NEW ROCHELLE, N. Y.

ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

CIRCLE 335 ON READER-SERVICE CARD

A CASE OF *Accuracy!*

The "COMMANDER" instruments described below have a 5-year accuracy guarantee. By using NBS or NRC reported values, total cumulative errors for a complete measurement system can be as low as ±.002%.

DAUPHINEE POTENTIOMETER TYPE 9144

ACCURACY ±.001%

A new 6-figure DC vernier potentiometer with a total measuring range of 2.101010V. *Accuracy is at least 10 x that of similar commercially available equipment.* Direct readout on 4 dials in increments of .1 μv (no slidewire). Thermal emf's less than .1 μv. Switch controlled ranges of x 1 & x .1. Contains 2 saturated standard cells in an internally thermostated enclosure. Completely "Self-Checking." *May be used with equal facility and accuracy as a Saturated Standard Cell or Resistance Comparator — and for the calibration of .01% accurate potentiometers.*

The Type 9144 is an original design by Dr. T. M. Dauphinee of the National Research Council in Canada. All rights are protected by a United States patent application.

VOLT RATIO BOX TYPE 9700

ACCURACY ±.005%

A volt ratio box similar to that used by the National Bureau of Standards as described by NBS Research Paper RP 1419. Self-heating and surface leakage negligible. Ranges: .15/.3/.45/.6/.75/1.5/3/4.5/6/7.5/15/30/45/60/75/150/300/450/600/750 V. (Type 9700A includes 1500 V. range). Furnished in a thermostated oil bath with a motor-driven impeller.

CONSTANT TEMPERATURE STANDARD CELL ENCLOSURE TYPE 9152 AND SATURATED STANDARD CELL TYPE 4305

ACCURACY ±.001%

Enclosure accommodates up to 4 cells and is air thermostated at 28C° ± .01°C. Transistorized circuit. Operates on 110V/60 cps (Battery standby). Type 9152A holds twelve cells.

THE TYPE 5214 GALVANOMETER AMPLIFIER AND TYPE SR21 LIGHT SPOT GALVANOMETER

The amplifier operates on the differential photocell principle in conjunction with a liquid-filled primary galvanometer. The secondary galvanometer has a scale length of 120-0-120 mm and is stable and free from the effects of external vibration. Over-all sensitivity is approximately 350,000 mm/μa and 35,000 mm/μv. It is ideally suited for use with the type 9144 potentiometer.

Sensitive Research "COMMANDER" Instruments are manufactured by Guildline Instruments, Ltd. (formerly Tinsley Instruments (Canada) Ltd.)

SENSITIVE RESEARCH INSTRUMENT CORPORATION

NEW ROCHELLE, N. Y.

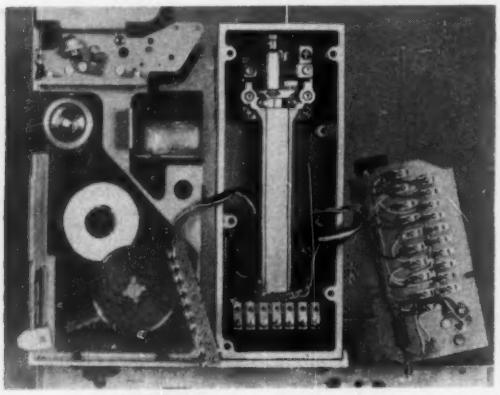
ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

CIRCLE 13 ON READER-SERVICE CARD

ICS NEWS

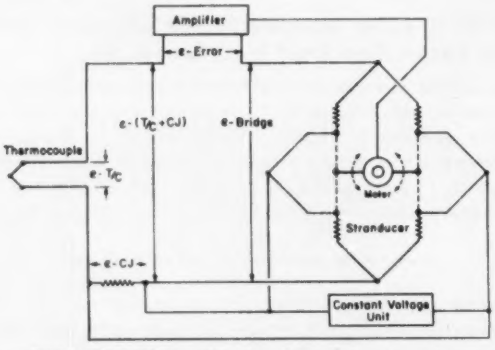
Strain-Gage Potentiometer Eliminates Slidewire

NEW YORK, N. Y.—A new industrial process potentiometer called the ElectroniK 17 and incorporating an extremely accurate, trouble-free electro-mechanical strain gage as the rebalancing element, is expected to "open up a new era in precision measurement and recording."



STRANDUCER rebalancing element.

In eliminating the conventional slidewire, long an objective of instrumentation engineers, infinite resolution is achieved for the first time in a potentiometer. No longer is the number of points at which a potentiometer can come to balance limited to the turns (convolutions) on a slidewire. As the "heart" of the ElectroniK 17, the Stranducer varies the output potential of the measuring circuit to balance the input signal from the process variable. Four prestressed looped wire strands enclosed in an I-shape frame form the variable resistance legs of the measuring circuit.

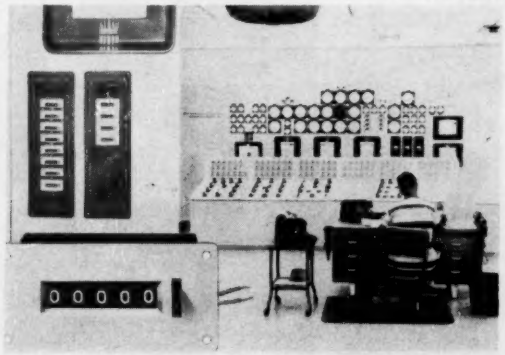


STRANDUCER self-balancing potentiometer.

At zero position, the wires, fastened to the pivot arm of the Stranducer, are in equal tension and are of equal resistance. The pivot arm, as it rocks back and forth, increases tension on two of the wires and decreases it on the other two wires. It is linked mechanically through sector and strap reduction stages and the drive cable to the balancing motor. Calibrated accuracy is ¼%. Strip-chart instruments have pen speeds of 1, 5 and 15 seconds. Those for circular chart instruments are 5 and 15 seconds. . . . (*From Specifications S172-1 & 2, S173-1 & 2, S176-1 & 2, Minneapolis-Honeywell Regulator Co., Wayne & Windrim Aves., Phila. 44, Pa.*)

FOR THIS LITERATURE CIRCLE 165 ON READER-SERVICE CARD

DURANT MFG. CO. has supplied the electric counters, installed in the main control room of the generating plant of Florida Power Corp., which record the opening and closing of the circuit breakers on the main generators.



They enable the operators to determine from a central location, how many times during a given period the various overload circuits have been thrown in automatically. (Durant Mfg. Co., 1914 N. Buffirm St., Milwaukee 1, Wis.)

IBM has created a new data processing systems engineering organization with an initial force of more than 1000 specialists who will "assure the best systems for all IBM machine users and develop breakthroughs along a wide front in the solution of advanced management and scientific problems." The titles in this group ("systems engineer—process control; s.e.—scientific; s-e.—banking") reflect the finely-combed skills. In addition, a supporting educational program was announced: The recently-opened IBM Systems Research Institute provides graduate-level studies for systems engineers working in specialized fields.

BURROUGHS CORP. new algebraic compiler, a high-speed automatic programming system, using ALGOL, the new international Algorithmic Language, cuts the time required to program a Burroughs 220 electronic computer by as much as 80%. (Burroughs Corp., Equipment and Systems Div., Detroit 32, Mich.)

FOR MORE INFORMATION CIRCLE 166 ON READER-SERVICE CARD

DATEX CORP. has designed and built an 80-point data logging system for the Detroit Arsenal which will sequentially scan, measure, and record 80 variables at the rate of one variable per punch, with the tape punch code being suitable for Datatron computer input. (Datex Corp., 1307 So. Myrtle Ave., Monrovia, Calif.)

TO THE ENGINEER

who can't tolerate a lapse of memory

If you're working on a think machine that can't afford to break its train of thought, consider AE's pint-size, fast-stepping OCS switcher. Unlike electron tubes and relays, this sophisticated device won't lose stored memory in the event of power failure or circuit interruption.

Besides, it can do the work normally assigned to whole banks of relays.

The AE Series OCS will follow or initiate a prescribed series of events or cycles at 30 steps per second impulse-controlled, or 65 steps per second self-interrupted. Any programming sequence can be set up on one to six cams with as many as 36 on-and-off steps per cam. And each cam will actuate as many as six contact springs.

In any event, if your designs involve relays or stepping switches, AE circuit engineers may be able to save you a pretty penny. Or, if you'd like to leave the switching to us, we're equipped to supply prewired and assembled, custom-built control units, *or* help you develop complete control systems.

To explore the matter, just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Also ask for Circular 1698-H: *Rotary Stepping Switches;* Circular 1702-E: *Relays for Industry;* and our new 32-page booklet on *Basic Circuits.*

AUTOMATIC ELECTRIC GENERAL SYSTEM

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

CIRCLE 15 ON READER-SERVICE CARD

ICS NEWS

New Standards Laboratories

HEMPSTEAD, N. Y.—PHYSICS RESEARCH LABORATORIES, Hempstead, N. Y., founded in 1952 as a consulting service to several fields of applied physics and

instrumentation, (also American representative to C. P. Goerz, Otto Wolff, and other instrument firms of Europe) has opened its laboratory facilities on a commercial basis. Industry now has available another primary standards electrical testing and calibration facility, using standards and basic measuring instruments traceable to the NBS.

Another "primary standards" laboratory has been opened in Northern California. The laboratory comprises a completely equipped calibration center for electrical and electronic instruments used in production and research, says Jay Dobrin, president, Western Scientific Instrument Company, 2431 Spring St., Redwood City, Calif.

CIRCLE 167 ON READER-SERVICE CARD

NATIONAL BUREAU OF STANDARDS, and Colorado University recently held the 1960 Cryogenic Engineering Conference with more than 750 scientists and engineers from industry, government, and universities attending.

ISA has issued five new Tentative Recommended Practices covering dynamic response testing; electrical installations in hazardous atmospheres, and orifice plates.

ASA has issued a new American Standard, Frenquencies for Acoustical Measurements, S1.6-1959 which refers all frequency-series to a single reference frequency. Eleven preferred frequencies are cited from 1 to 16,000 cps.

Infrared Thermometry School

CHICAGO, ILL.—First of its kind in the country, an Infrared Thermometry school for industrial instrumentation personnel has been established by Radiation Electronics Company, Chicago 48, Ill. Thirty students from many different industries attended the opening laboratory

and lecture sessions on Nov. 15. The two-day course is conducted by *Herbert L. Berman* and *Dr. Arthur E. Goldberg* of Radiation Electronics Co., a division of Comptometer Corporation, leading producer of infrared components, instruments, and systems. Lectures cover principles and applications of infrared sources, infrared sensing devices, optical materials, radiation thermometers, and remote temperature measurement and control. Laboratory sessions are devoted to: emissivity, glass and flame temperatures, thermal scanning, and temperature control. Courses are scheduled at monthly intervals. The next two courses are scheduled for Jan. 10-11, and Feb. 13-14. Inquiries should be addressed to: R. Van Scoyoe, Radiation Electronics Co., 5600 Jarvis Ave., Chicago 48, Ill.

CIRCLE 168 ON READER-SERVICE CARD

INDUSTRIAL ACOUSTICS CO. has started a new service to lease noise control equipment such as soundproof rooms, anechoic chambers, jet aircraft ground run-up silencers, etc.

CLEVELAND INSTITUTE OF ELECTRONICS is giving a new master course in electronics for established technicians who desire training in the more important specialized applications of electronics.

AEROTEST LABS has opened a new gas dynamics test facility at its Deer Park, L. I., N. Y. location.

LITTON INDUSTRIES' Space Research Lab and the Airforce Office of Scientific Research have announced development of a device, called an "electromagnetic plasma accelerator," whereby hot, ionized gases can be propelled at speeds exceeding 250,000 miles/hr. This device will pave the way for development of advanced space propulsion systems.

LING ELECTRONICS, a division of Ling-Altec Electronics, Inc., has started a series of courses on vibration testing at their plant in Anaheim, Calif., which cover sine-wave-, complex-sine-, and random-vibration. The course will be repeated monthly.

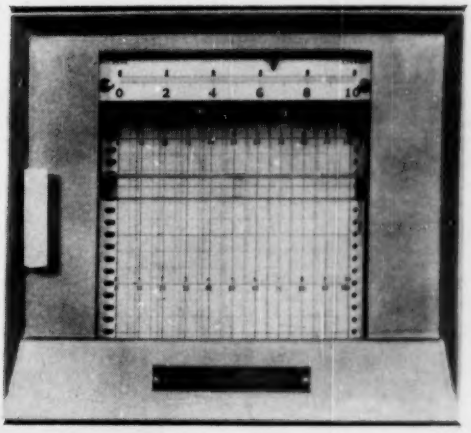
if PANEL SPACE or PORTABILITY is your problem...

The Westronics Miniature MULTIPOINT Recorder Model M5A is your perfect solution.

The panel space occupied by the Westronics Miniature MULTIPOINT Recorder is only 8½ x 9⅝ inches, or only 25% of the panel space required by most large case recorders.

The Westronics Miniature MULTIPOINT Recorder scans and measures 2 to 12 different input sources at the rate of 5 seconds per point.

Westronics manufactures a complete line of miniature and full size recorders with more optional features than any other manufacturer.



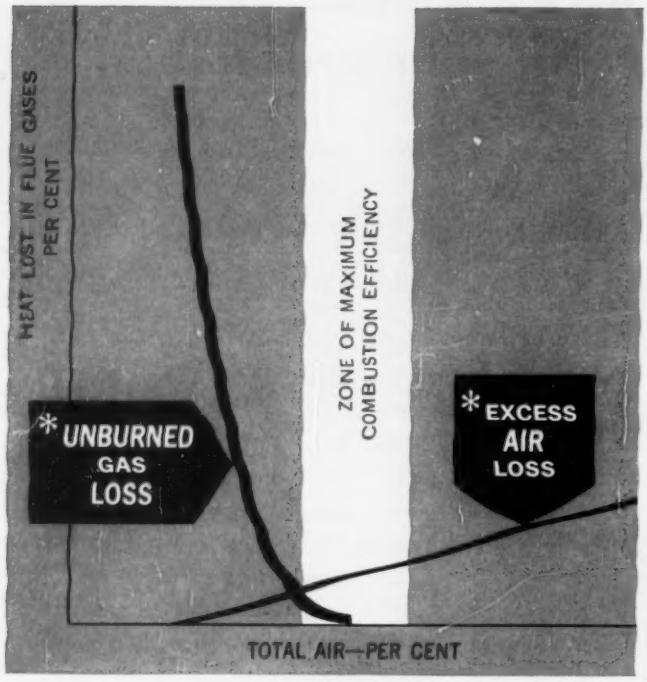
STANDARD UNITS AVAILABLE FROM STOCK. SPECIFICATIONS UPON REQUEST.

westronics, inc.

TWX FT 8248 U • 3605 McCART STREET • FORT WORTH, TEXAS

CIRCLE 16 ON READER-SERVICE CARD

You must know BOTH* to get maximum combustion efficiency!

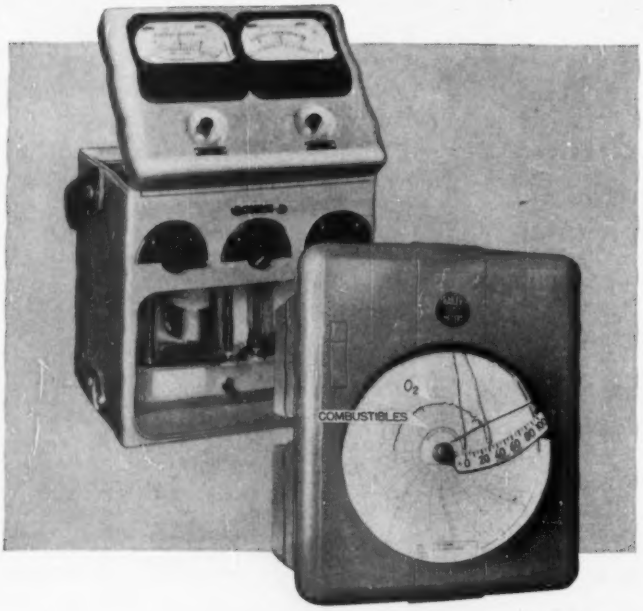

HEAT LOST IN FLUE GASES PER CENT
ZONE OF MAXIMUM COMBUSTION EFFICIENCY
* UNBURNED GAS LOSS
* EXCESS AIR LOSS
TOTAL AIR—PER CENT

How much money is going up the flue in *unburned fuel* losses? Is too much air resulting in excessive *heat* losses?

You must know *both* facts—simultaneously—to get optimum combustion. No instrument that measures only one of these interdependent factors can give you the full information you need.

Bailey offers a choice of two direct ways to maintain a continuous and simultaneous *double check on these factors that determine* combustion efficiency. The portable, lightweight Bailey HEAT PROVER Analyzer indicates both; the Bailey Oxygen-Combustibles Analyzer-Recorder records both on a single *chart. Both instruments measure excess air,* regardless of fuel or fuels being burned, and per cent of combustibles in flue gas.

Either of these Bailey instruments can save you far more than their cost in spotlighting *combustion inefficiencies. Ask your Bailey* engineer or write for product specifications.



2 DIRECT WAYS to measure both combustibles and oxygen simultaneously

PORTABLE INDICATOR—Self-contained, lightweight, Bailey HEAT PROVER Analyzer enables quick, easy check on combustion conditions. Dual range dials for greater accuracy and readability.

PERMANENT RECORDER—Bailey Oxygen-Combustibles Analyzer-Recorder coordinates both records on one chart . . . is designed for permanent installation . . . helps maintain optimum ratio continuously.

* Unburned gas loss and excess air loss.

G 155-1

Instruments and controls for power and process

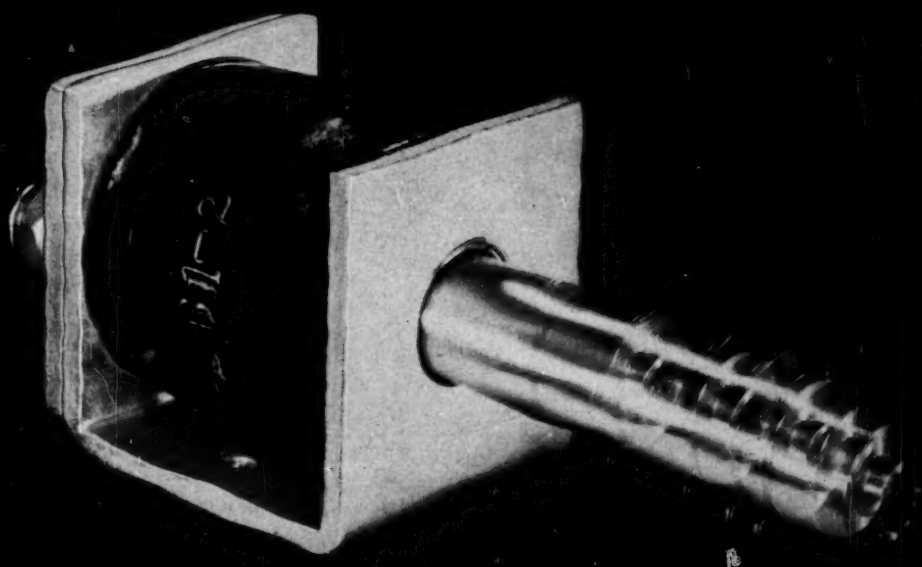
BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

CIRCLE 17 ON READER-SERVICE CARD

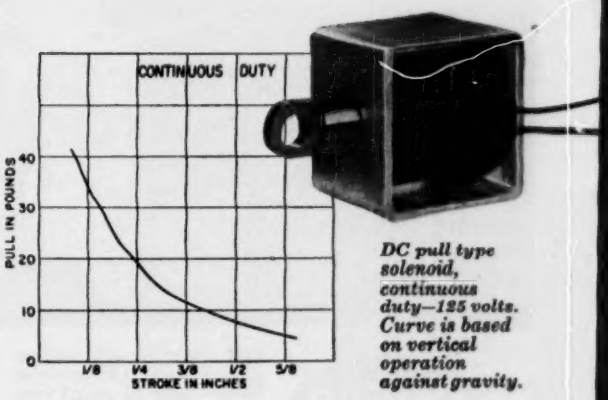
100 MILLION OPERATIONS!



new ASCO solenoid has virtually unlimited life... outstanding economy

In this case "unlimited life" is a simple statement of fact. ASCO's new solenoid is manufactured to such precise tolerances (±0.0005") that wear is virtually non-existent. In ordinary solenoids, the plunger rides loosely in the sleeve—inviting wear. But in ASCO's long-life solenoid, the plunger is guided by a machine tool bearing that assures accurate stroking and reduces friction to an absolute minimum.

Because this solenoid was engineered with quality as the prime consideration, its initial cost is higher. However, it is in fact *the most economical solenoid you can buy* because, once installed, it can practically be forgotten. This solenoid will still be functioning 100 million operations later—long after standard types have been replaced—and replaced—and replaced. For additional information, contact your ASCO engineer or write for Catalog 57-S5.



DC pull type solenoid, continuous duty—125 volts. Curve is based on vertical operation against gravity.

ASCO Electromagnetic Control

Automatic Switch Co. 52-L HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

ASCO

CIRCLE 18 ON READER-SERVICE CARD

Select from over 3,500 different SOLENOID VALVES from VALCOR

Series SV-54 (3 way-4 way) general purpose solenoid valves for air, oil and water. Rugged construction, yet inexpensive. Multi-million cycle life. Pressure ratings up to 150 psi. Nylon seat outlasts steel. Infinite varieties available . . . lists as low as $10.75.

Series SV-61 (2 way) Nylon body valve is ideal for general purpose and OEM installations where millions of operating cycles are vital. Nylon seat and port threads outlast steel, yet cost less. Non-corrosive, shock-resistant, proof-pressure.

Series SV-5100 Specifically designed to handle the most corrosive media in industry. Manufactured in Teflon, PVC and Nylon varieties. Diaphragm construction prevents media contact with any metal. Available in direct-acting or piloted models.

VALCOR SOLENOID VALVES

FREE...new 16 page brochure —lists over 500 corrosive media—coded for correct valve selection.

For complete information on these or other models, write or call:

VALCOR ENGINEERING CORP.
5366 Carnegie Ave., Kenilworth, N. J.
CHestnut 5-1665

CIRCLE 19 ON READER-SERVICE CARD

I&S STOCK REPORT

Further information may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

NEW YORK STOCK EXCHANGE

PRICE RANGE FOR 1960 THRU December 15, 1960

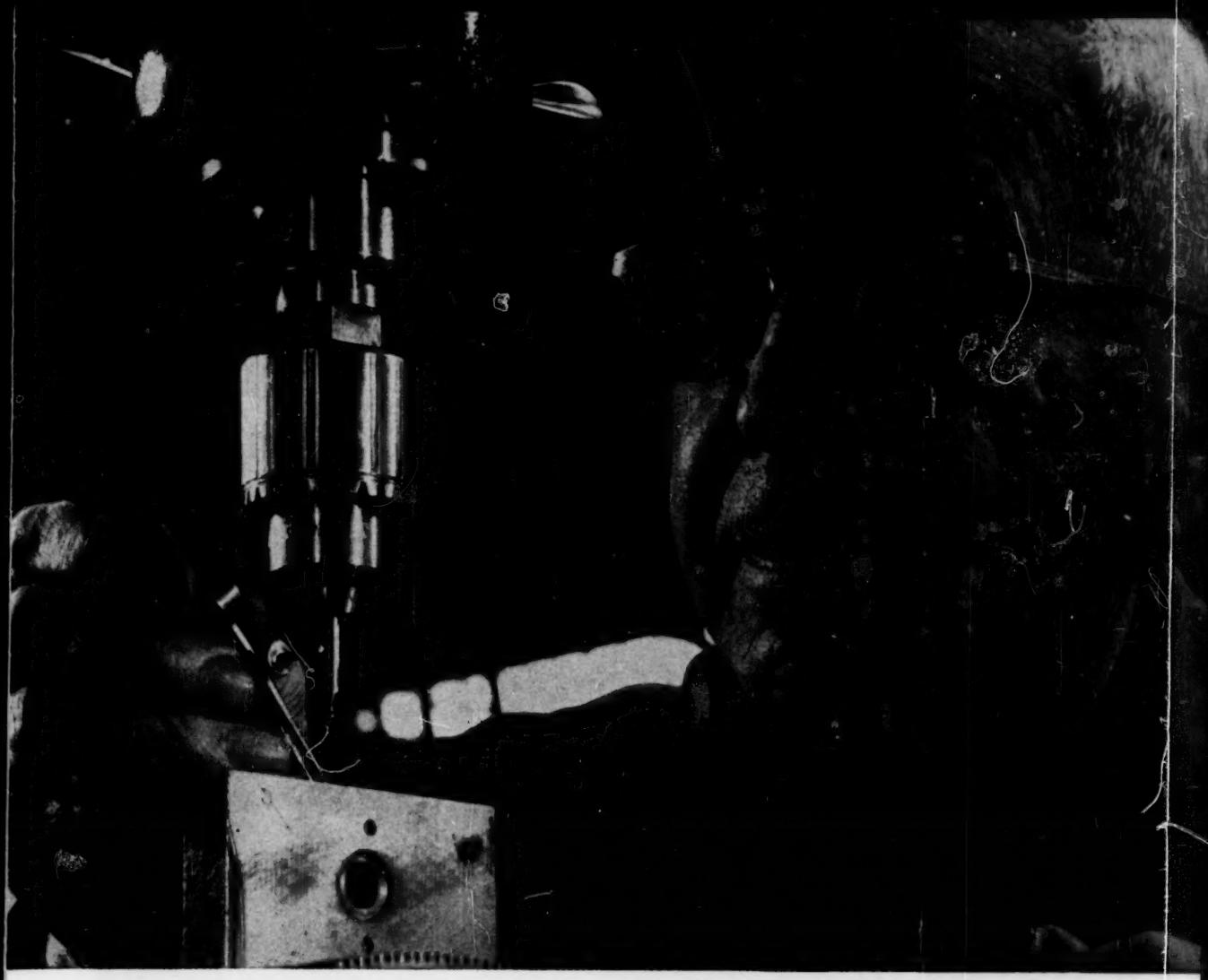
	High	Low	Price As Of 12/15/60
ACF Industries	52	35 1/8	38 7/8
Aeroquip Corp.	40 5/8	22	24 5/8
Allis Chalmers	40	22	23 7/8
American Chain & Cable	51 3/4	40 1/4	42 1/4
Amer. Mach. & Foundry	89 1/2	49 1/2	89 1/2
Amer. Mach. & Metals	88 1/4	31 3/4	35 1/4
American Optical	67	43 1/4	57 3/4
Amer. Tel. & Tel.	97 5/8	79 7/8	93 5/8
Ampex Corp.	42 1/4	19 1/2	23 3/4
Aro Equipment	25 7/8	19	20 3/4
Bausch & Lomb Optical	58 7/8	34 1/2	41
Beckman Instruments	103 3/4	62 1/2	92 1/2
Bell & Howell	57 1/2	37 5/8	52 3/4
Bendix Aviation	74 1/2	46 1/4	65 1/4
Boeing Airplane	39 1/8	23	38
Bullard	17 7/8	10 3/8	11 3/4
Bulova Watch	23 3/4	14 1/8	16 1/4
Burroughs	40 3/8	26 1/4	27 3/4
Carborundum	49 7/8	39 1/4	47 1/2
Cinn. Milling Machine	38 1/2	26 1/2	37 7/8
Clevite	72 1/2	42	54 1/2
Columbia Broadcasting Sys.	45 1/4	34	34 5/8
Consol. Electronics	60 3/4	42 1/4	47 1/4
Corning Glass	186	124	178 1/4
Curtiss Wright	31 1/8	14 5/8	15 3/4
Cutler-Hammer	96	67 1/4	74
Daystrom	49 3/8	27 1/2	31 7/8
Douglas Aircraft	42 3/8	27	30 1/8
Eastman Kodak	136 1/4	94	112 1/8
Eaton Mfg.	46 7/8	28 1/2	30 5/8
Electric Auto-Lite	54 1/2	44 1/2	46
Elgin Watch	19 1/8	10 1/2	11 7/8
Emerson Electric	53 1/2	33	52 1/4
Engelhard Industries	23	16 3/4	18 1/4
Food Mach. & Chem.	58 3/4	44 1/2	58 1/2
Garrett	59	43 1/8	52 3/8
General Controls	29 5/8	15 3/4	19 3/8
General Dynamics	53 3/8	33 1/2	42
General Electric	99 7/8	70 1/4	75 5/8
General Instruments	50 3/8	22 1/2	41
General Mills	32 1/4	23 7/8	32 1/4
Gen. Precision Equip.	66 5/8	43 1/2	55 7/8
Gen. Railway Signal	36 7/8	23 1/4	30 1/2
Gen. Tel. & Elect.	34 1/8	23 3/4	27
General Time	33 1/8	13 1/2	13 1/4
General Tire & Rubber	81 3/8	41 5/8	55 3/4
International Bus. Mach.	596	407 1/4	583 1/2
International Resistance	41 5/8	18 1/4	30 3/8
Internat'l. Tel. & Tel.	46 3/4	32	45
I-T-E Circuit Breaker	44 1/4	18 1/8	21
Lear Inc.	23 1/2	13 5/8	18 1/2
Litton Industries	96	57 5/8	90 7/8
Lockheed Aircraft	32 7/8	18 5/8	28 1/8
Magnavox	55	31 3/4	45 7/8
Mallory	50 1/4	33	37 5/8
Manning, Maxwell & Moore	27 1/2	19 5/8	20 3/4
Minneapolis-Honeywell	178 3/4	123 5/8	142
Minnesota Mining & Mfg.	88	60	74
Motorola	98	60 1/2	78 1/2
National Acme	54 3/4	40	44 1/4
National Cash Register	70 7/8	49 7/8	60 1/2
Neptune Meter	34 3/8	24	28 1/8
North American Aviation	47	29 5/8	46 1/2
Northrop Aircraft	47	24 3/4	45 3/4
Otis Elevator	58 1/2	36 1/4	58 1/2
Philco Corp.	38 1/4	15 7/8	18
Radio Corp. of Amer.	78 3/8	46 1/2	53 1/8
Raytheon Mfg.	53 3/8	30 1/4	36 5/8
Reliance Electric	68 5/8	43 1/8	48
Rheem Mfg.	28 7/8	12	14 1/4
Robertshaw Fulton	55	33 1/4	37 1/2
Royal Mc Bee	21 3/8	11 7/8	13 7/8
Sangamo Electric	21 1/2	13 1/8	13 3/4
Siegler Corp.	43	23 5/8	29 5/8
Sperry Rand	26 1/4	18 3/8	21
Square D	37 7/8	25 1/2	30 1/4
Standard Kollsman	30 1/2	12 5/8	26 7/8
Starrett (L.S.)	20	16	17 3/4
Stewart-Warner	33 1/2	23	25 1/2
Telautograph	24 1/2	6 7/8	13 5/8
Texas Instruments	256 1/4	148 1/4	192
Thompson-Ramo-Wooldridge	67 1/2	46 7/8	63 1/2
Tung-Sol Electric	40 1/2	28	29 3/4
Underwood Corp.	57	34 3/4	52
Union Carbide Corp.	148 1/2	106 1/2	121 5/8
United Shoe Machinery	64 3/8	50	58 5/8
Varian Associates	67 1/2	38 1/8	51 5/8
Wallace & Tiernan	69 1/4	41	57
Western Union	57	38 1/4	41 1/8
Westinghouse Air Brake	32 5/8	21 1/8	22 5/8
Westinghouse Electric	65	45	52 1/4
Worthington Corp.	66	41 1/2	48 3/4

These prices and price ranges are given as printed in the Wall Street Journal.

AMERICAN STOCK EXCHANGE

PRICE RANGE 1960 THRU DECEMBER 15, 1960

	High	Low	Price As Of 12/15/60
American Meter	52	39	41 3/4
Barry Wright Corp.	25 1/2	13 5/8	16 3/4
Belock Instruments	25 3/8	13 1/8	16 7/8
Benrus Watch	8 7/8	5 3/8	7 1/8
Breeze Corp.	8 5/8	4	4
Burnell & Co.	9	6 1/8	6 1/8
Clark Controller	23 5/8	15 1/2	16 1/2
Clarostat Mfg.	16 3/8	9 7/8	13 5/8
Clary Corp.	11 1/2	6 3/4	9 7/8
Cubic Corp.	69	39 5/8	57
Dynamics Corp. of Amer.	13 3/4	6 5/8	8 1/8
El-Tronics	8 1/8	4	6 5/8



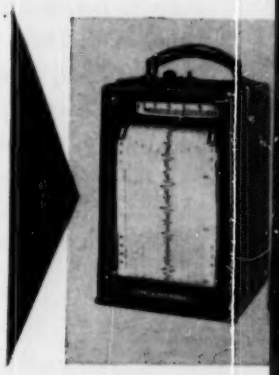
At Esterline-Angus, the past becomes the future

● Our experience of over 50 years . . . the skill of our master craftsmen . . . complement perfectly the new forward-looking, creative work of our engineering staff. The result? Modern graphic recording instruments unequaled in design as well as workmanship and material.

We're continuously developing new instrument designs and applications. All are carefully built and tested to assure trouble-free performance under even the most severe operating conditions. That's why Esterline-Angus recording instruments offer you the highest reliability rating in the industry. Many of our very first instruments are *still* functioning accurately. Ten, twenty, thirty years of dependable operation are not unusual.

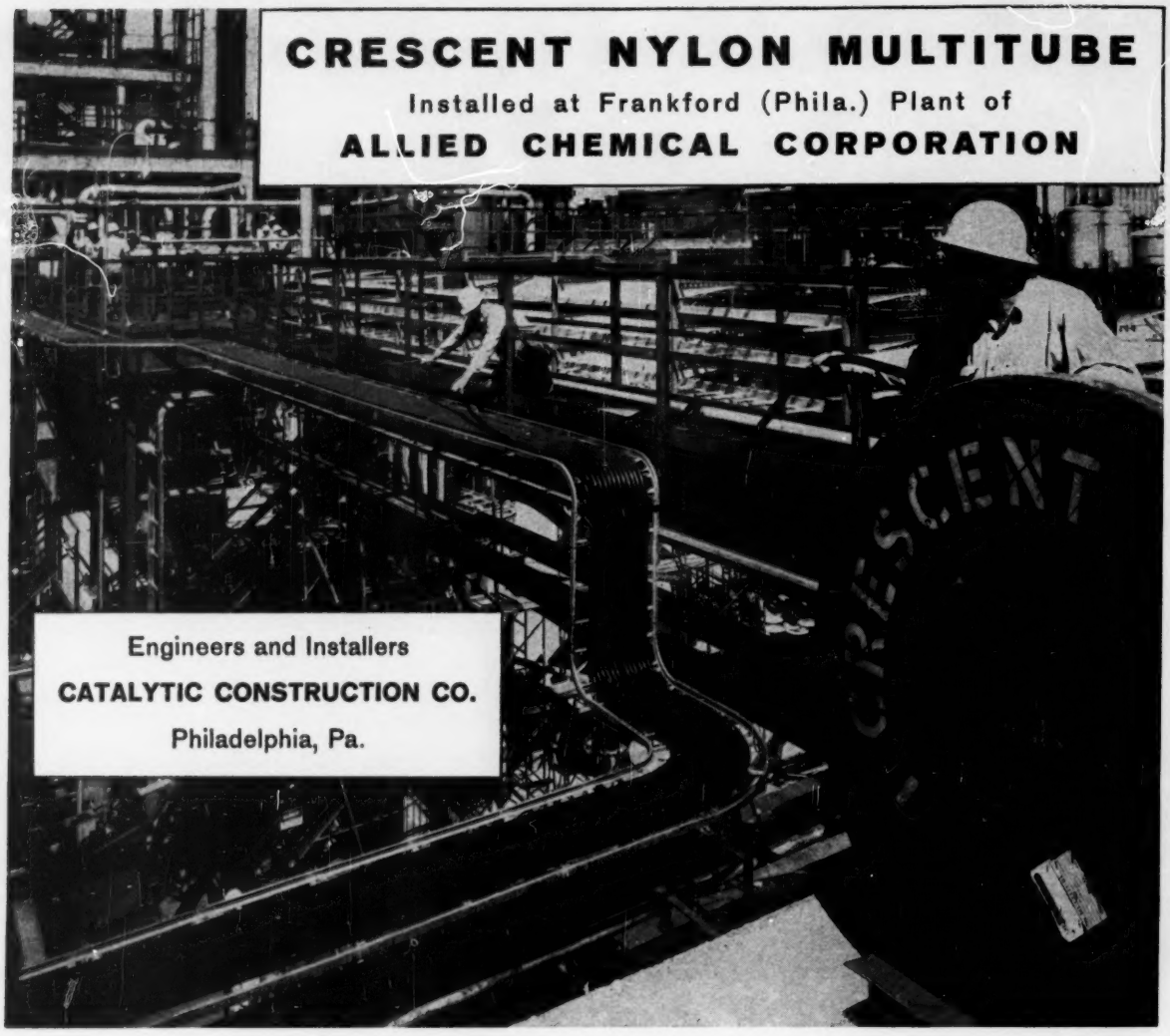
Insist on modern recording instruments by Esterline-Angus . . . where master craftsmen's skill is successfully teamed with space-age technology.

Write for case histories, "How to cut production costs, increase maintenance efficiency and aid research with Esterline-Angus Graphic Instruments." Address: THE ESTERLINE-ANGUS INSTRUMENT COMPANY, Box 596G, Indianapolis 6, Indiana.



Finer graphic instruments for over 50 years—ESTERLINE-ANGUS

CIRCLE 20 ON READER-SERVICE CARD



Eight miles of CRESCENT NYLON Tubing made from Allied Chemical Corporation's PLASKON® NYLON, in the form of MULTITUBE, is installed in this large chemical plant for purposes of instrument control.

Each MULTITUBE cable shown in this picture contains 14 nylon tubes spirally cabled together, which permits maximum bending without distortion of the tubes. The assembly is protected by a Mylar® tape, as well as a weather, corrosion and flame resistant PVC thermoplastic sheath.

Nylon Tubing offers excellent resistance to environmental deterioration, impact and abrasion coupled with unusually high fatigue resistance over a broad temperature range. It is less expensive than copper tubing, and is particularly easy to install. Individually numbered tubes, with numbers clearly visible every 2 inches, make it easy to identify tubes at either end.

CRESCENT makes many types of MULTITUBE, using copper, aluminum, steel, polyethylene or nylon tubes, with a great variety of protective sheaths, including interlocked metal armor.

Send for NEW Bulletin No. 960-A with complete engineering data, diagrams, etc.

CRESCENT INSULATED WIRE & CABLE CO.

Trenton 5, New Jersey

CIRCLE 21 ON READER-SERVICE CARD

AMERICAN STOCK EXCHANGE

Continued from page 26

Electronics Corp. of Amer.	19 1/2		
Fairchild Camera & Instrument	201 3/4	106 1/2	1/2
Giannini Controls	68 3/8	39	
Globe Union	34 3/4	20 5/8	
Haseltine Corp.	31 1/2	20	
Loral-Electronics (new) (a)	36 1/2	23 1/8	
National Research	23 1/8	13 1/8	
New Haven Clock	2 7/8	1	1
Nuclear Corp. of Amer.	5 1/8	2 1/8	4
Philips Electronics, Inc.	47 3/8	31 1/2	37 1/
Pneumatic Scale	39 3/4	35	39
Polarad Electronics	36 5/8	17	21 3/4
Servo Corp. of Amer.	24 1/2	9 1/4	10 5/8
Servomechanisms	16	7 1/2	7 7/8
Statham Instruments Inc.	40 1/4	25 3/4	29 1/8
Textron Electronics	18 3/4	8 5/8	9 3/4
Victoreen Instrument Co.	17 1/2	9 3/4	13 1/2
Waltham Prec. Instr. Co.	3 1/2	1 1/4	1 3/4

These Prices and price ranges are given as printed in the Wall Street Journal.

Barry Controls merged with Wright Line Inc., new name is Barry Wright Corp.

(a) Stock split 3-for-1.

OVER THE COUNTER

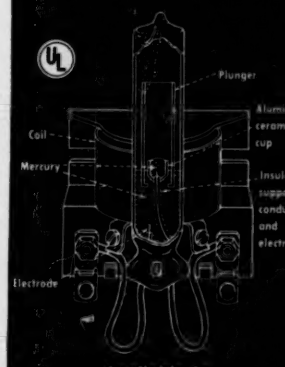
	Quotation As of December 15, 1960	
	Bid	Asked
Aerovox Corp.	7 1/4	8
Argus Corp.	32	33
Computer Systems	7 1/2	8
Bleck Sivalls & Bryson Inc.	11 5/8	12 1/4
Bitel Mc Cullough	15	15 3/4
Electro Instruments	23	24 1/2
Electronics Associates	30	30 3/4
Erie Resistor Corporation	8 1/2	8 7/8
Fisher Governor Co.	18 3/4	19 1/4
Foxboro Company (new)	43 1/2	44 1/2
Hagan Chemicals & Controls	44 1/2	45 1/2
Industro Transitor	5 1/8	5 1/2
Liquidometer Corp.	17 1/2	18 1/4
W. L. Maxson	7	7 1/2
Penn Controls	19 1/2	20 1/4
Speer Carbon, Inc.	18 1/4	19 1/4
Sprague Electric	53 1/2	54 3/4
Taylor Instruments (new)	32 1/2	33 1/2
Telechrome Mfg. Corp.	13	13 3/4
Telecomputing Corp.	8 1/8	8 1/2
Vitro Corp. of Amer.	9 3/4	10 1/8

FREE

ENGINEER'S FACT FILE

MERCURY PLUNGER RELAYS

From 20 to 100 AMPS



Available in Single Pole, Double Pole or Triple Pole Units

FREE: Practical reference manual. Fully illustrated. Covers all types and uses of Mercury Plunger Relays that provide millions of makes and breaks without maintenance. Constant, uniform action. Hermetically sealed, silent and reliable, trouble-free!

Send for your copy. You will find it useful.

EBERT ELECTRONICS CORP.

212-A93 Jamaica Ave., Queens Village 28, N. Y.

CANADA: Philips Electronics Industries Ltd., Toronto 17

EXPORT: Philips Export Co., New York City

CIRCLE 22 ON READER-SERVICE CARD

MODEL HA 150R
A 60 kV unit is also available.

CARL ZEISS

NEW

High Voltage Supply Unit

with built-in electronic stabilizer. 150 *kV D.C.*

Made in West Germany

This new unit embodies the most advanced features and offers important advantages in research and technical fields. It can be used for: High voltage supply for electron-optical examinations . . . Examinations of structure by means of electron diffraction . . . Deflecting voltage for particle accelerators . . . High voltage source for neutron generators . . . Electric testing of materials . . . Electrostatic spraying . . . Electronic sorting . . . High voltage supply during lectures, etc.

A safety device is incorporated to protect the operator against being subjected to dangerous high-voltage discharges. The unit is free of disturbing high-frequency radiation, and has only small interfering magnetic fields. Line voltage fluctuations of ±10% have practically no influence upon output. Mounted on casters —easily movable.

Write for literature.

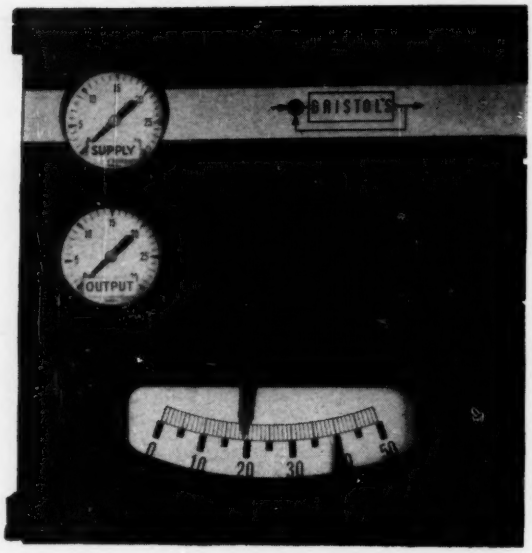
COMPLETE SERVICE FACILITIES

CARL ZEISS, INC.

485 FIFTH AVENUE, NEW YORK 17, N. Y.

CIRCLE 23 ON READER-SERVICE CARD

NEW BRISTOL'S



Series 624 A/D* pneumatic controller features simplicity and high control stability

- **Simple modular design for ease of servicing**
- **High control stability for closer process control**
- **Designed for batch-type and continuous processes**
- **Proportional and proportional-plus-reset control models available**

Top control performance with maximum simplicity plus standard Bristol precision measuring elements—those are the key features of the Bristol Series 624 Controller. The 624 uses the same renowned elements that have earned such a reputation for accuracy and dependability on other Bristol automatic controlling and recording instruments—perfected through wide experience and many years of development.

Self-contained modular design of the control unit speeds servicing. The whole modular unit, consisting of an aluminum casting with working parts made of stainless steel, Ni-Span C, and Neoprene diaphragms, can be removed by taking out only two screws and a link.

Outstandingly compact, the aluminum instrument case (only 8" x 8" x 5" overall) is completely weatherproof. It is designed for either flush, surface, panel, or valve mounting. Attachments for pipe mounting (2-inch pipe) are available. Write for complete data on the versatile and economical 624 A/D. The Bristol Company, 113 Bristol Road, Waterbury 20, Conn. 0.35

**Advanced Design*

CONTROLLERS OFFERED FOR:

PRESSURE AND VACUUM: Ranges from full vacuum to 10,000 psi.

TEMPERATURE: Ranges from —100°F to +1000°F.

FLOW AND DIFFERENTIAL PRESSURE: With mercury-type manometer and dry-type differential unit.

LIQUID LEVEL: With bulb unit and mercury manometer and dry-type differential unit.

HUMIDITY: Zero to 100% relative humidity.

CONTROL UNIT CHARACTERISTICS:

PROPORTIONAL BAND: 0-400% continuously adjustable, direct- or reverse-acting.

RESET: 0.1 to 50 repeats per minute.

AIR PILOT: Non-bleed type.

PILOT CAPACITY: 3.0 scfm.

FREQUENCY RESPONSE: Flat to 300 cycles per minute.

TEMPERATURE STABILITY: Less than 0.25% change in the output pressure for 90°F temperature change.

MATERIAL: Aluminum housing; 316 stainless steel internal parts; Ni-Span C feedback element.

BRISTOL... for improved production through measurement and control

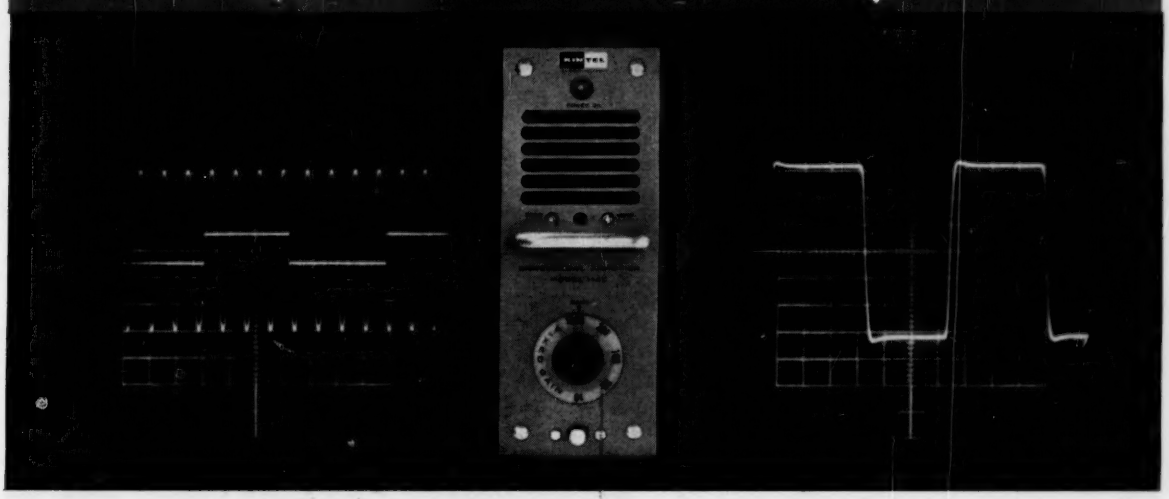
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

CIRCLE 24 ON READER-SERVICE CARD

(picture of a KIN TEL differential amplifier at work)

6 volts of 60∿ common-mode noise and 6 millivolts of signal in here

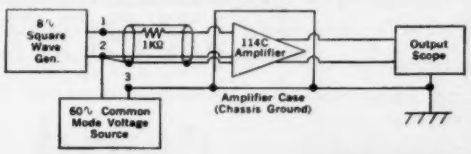
2 microvolts of 60∿ noise (equivalent input) and 6 volts of signal out here



If you measure the output of thermocouples, and the thermocouples are bonded to a rocket engine or almost any other grounded object, and the distance between thermocouples and amplifiers is more than a few feet, you should consider the above illustration carefully. While we'll admit your thermocouples probably aren't producing square waves, nine chances out of ten you *do* have a problem with 60-cycle common-mode noise. Nearly everybody does.

What can be done about it? Well, KIN TEL differential amplifiers reject ruinous 60-cycle common-mode hum and noise by a factor of 3,000,000 to 1 with any unbalance up to 1000 ohms in series with either side of the input, 1,000,000 to 1 with 10,000 ohms unbalance. Rejection for DC is practically infinite and both input and output can be floated up to ±300 volts DC or peak AC. The secret of this exceptionally high common-mode rejection in the presence of high input unbalance is isolation. Input signal terminals are isolated from chassis ground by 10,000,000 megohms and 0.6 micromicrofarads. Input and output signal terminals are completely isolated from each other. Output signal terminals are isolated from ground to almost the same extent as the input. With this virtually perfect isolation, you can rescue microvolt level signals from volts of common-mode noise, regardless of whether load and transducer are floating or grounded, balanced or unbalanced.

Before you send us that letter... the input scope photo is a double exposure. The square wave input signal was taken with the scope connected across points 1 and 2 (see drawing below) with 5 mv/division sensitivity. To show the noise, the scope was connected between points 2 and 3, and sensitivity was 1 v/division. The scope on the output was set for 1 v/division sensitivity and, of course, no noise is evident.



Specifications other than common-mode rejection are equally impressive. Linearity is 0.01% of full scale (10 volt) output for either polarity, 0.02% of full scale for plus-to-minus or minus-to-plus polarities. Equivalent input drift is less than 2μv; noise at full amplifier bandwidth is less than 6μv. Input impedance is 30 megohms, output impedance less than 0.25 ohms. Standard bandwidth is less than 3 db down at 80 cps, and the amplifier settles to within 99.9% of final value within 50 milliseconds for an output change of 5 volts. Plug-in input and output filters allow bandwidth options from 3 cps to 120 cps, transient response as good as 25 milliseconds. Gain is 10 to 1000 in 5 steps. A front panel vernier control provides 1 to greater than 3.3 times continuous adjustment of each gain step. Gain stability is ±0.05%. Output capability is 10 volts at 10 milliamps. Amplifiers have integral power supplies. Enclosures include six-amplifier and single-amplifier 19-inch rack modules, and portable single amplifier cabinets.

To meet your exact requirements at minimum cost, two models are now available: the 114A at $775, and the 114C (described) at $875. Delivery on both models is currently from stock. Write for detailed technical data or a demonstration. Engineering representatives in all major cities.

KIN TEL
A DIVISION OF
COHU
ELECTRONICS, INC.

5725 Kearny Villa Road, San Diego 11, California
Phone: BRowning 7-6700

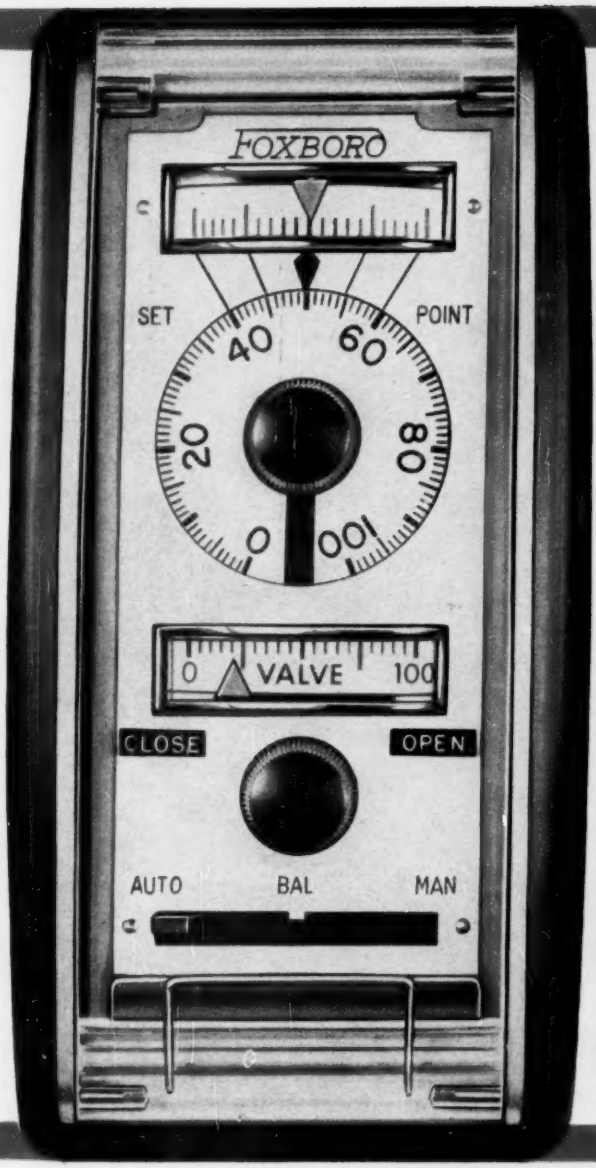
CIRCLE 25 ON READER-SERVICE CARD

Measurement deviation...

plus indication...

plus valve position...

you get them all with this **Foxboro electronic control station**



Shown here actual size→

One 3" x 6" panel station containing all control and supervisory functions — that's the Foxboro Electronic Consotrol* Controller. All d-c input — all d-c output — all solid state. Operates completely independent from recording.

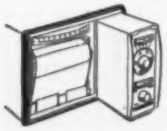
And look at these other features:

- measurement and deviation indicator gives continuous indication of process measurement as well as showing the deviation from set point.
- calibrated set point dial, with 4¾" scale, used with deviation indicator for readability of ½% full scale.
- valve position indicator for continuous, horizontal-scale indication of valve opening.
- simple auto-manual transfer switch for smooth, bumpless transfer.

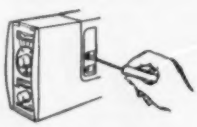
Foxboro electronic Consotrol control stations are available for cascade, ratio and auto-selector systems. Ask your Foxboro Field Engineer about them — or write for Bulletin 21-10. The Foxboro Company, 461 Neponset Avenue, Foxboro, Massachusetts.

Reg. U. S. Pat. Off.

Standard 9" x 6" housing holds 3 control stations, or 1 station with a companion recorder.



Controller and recorder each slide out from panel for easy servicing.



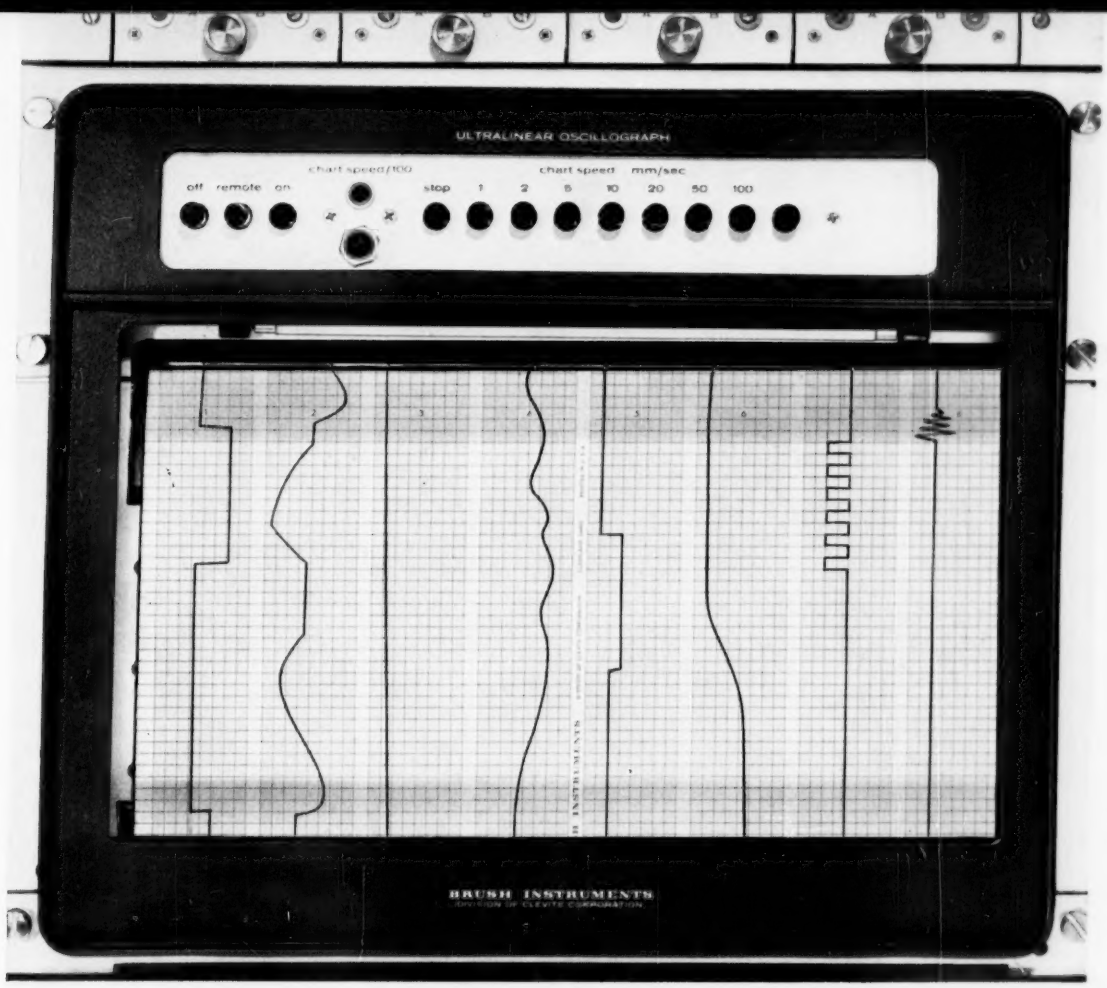
Proportional — reset — derivative: all adjusted from the front.

FOXBORO

REG. U. S. PAT. OFF.

CIRCLE 26 ON READER-SERVICE CARD

CIRCLE 27 ON READER-SERVICE CARD →



in multi-channel recording systems there is nothing newer

. . . There are many reasons why Brush's newest oscillograph is the ideal choice for today's most advanced telemetry and computer systems. Its precision and reliability are proven. You get analog data instantly recorded on eight 40mm channels . . . and the sharpest traces on rectilinear coordinates you've ever seen. Thirteen electrically controlled chart speeds take the guesswork out of interpretation. *All* functions are operated by pushbutton . . . including an ingenious auto-load chart changing arrangement. But . . . the most important reason of all is that this vertical panel oscillograph carries the name "Brush". No one is as qualified. See for yourself. Call, write or wire.

brush INSTRUMENTS

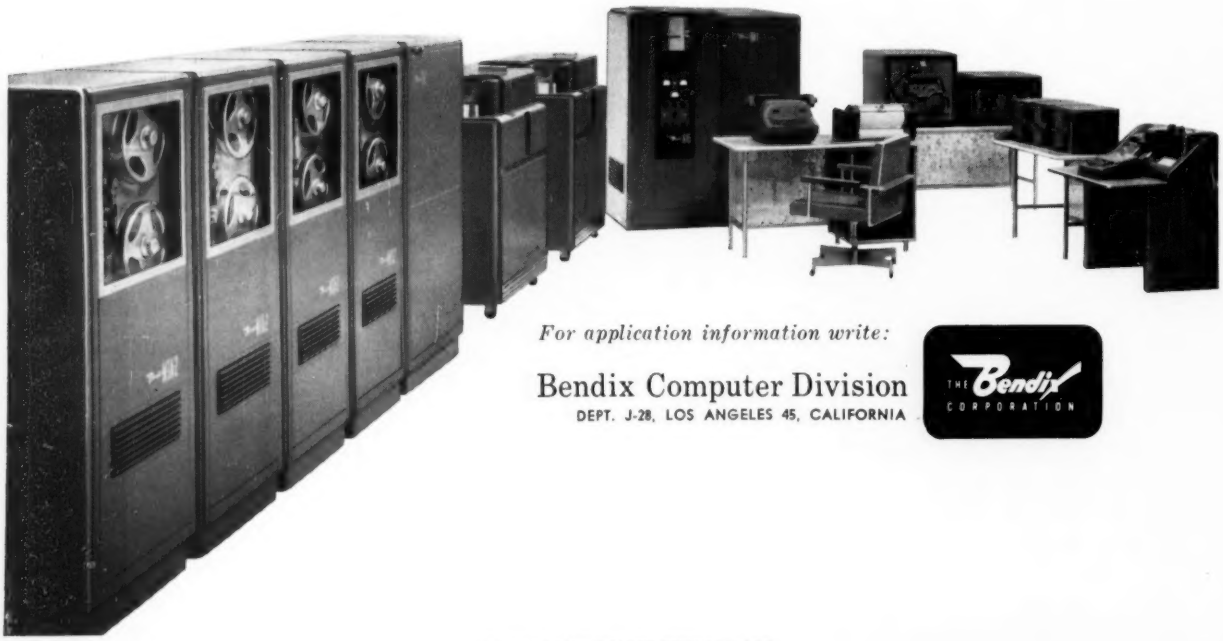
DIVISION OF CLEVITE CORPORATION

37TH AND PERKINS CLEVELAND 14, OHIO

WITH THE BENDIX
G-15 COMPUTER YOU CAN

START NOW

THERE IS NO NEED TO DELAY that *important decision to install a computer.* At a low initial investment . . . without adding special personnel or facilities, you can *start now* to provide your firm with the money-saving speed and precision of proven electronic computation. ● And you can inaugurate your computer program with the foreknowledge that *the G-15 can be easily expanded, easily adapted to your computational growth* . . . without re-programming, without awkward modifications. You know from the beginning that your G-15 will be able to easily assimilate the full range of input-output devices—paper tape, punched cards and magnetic tape, in addition to special code conversion, printing and graphic output units . . . all proven in a wide variety of applications. Simplified, minimum-cost application expansion is made possible by an extensive library of Bendix routines and automatic programming systems. ● Thus, with equal efficiency, the G-15 has served a one-man company and corporations of many thousands. More important, that one-man company has grown to a team of 47—still economically served by an enlarged G-15 system. ● These facts point to the practical economy and ease of initiating your data processing program . . . moving from a low cost basic G-15 computer to a powerful, integrated medium-scale system, capable of spanning the full range of scientific and commercial applications. They make clear that there is a G-15 system to match your data processing requirements . . . *starting now.*

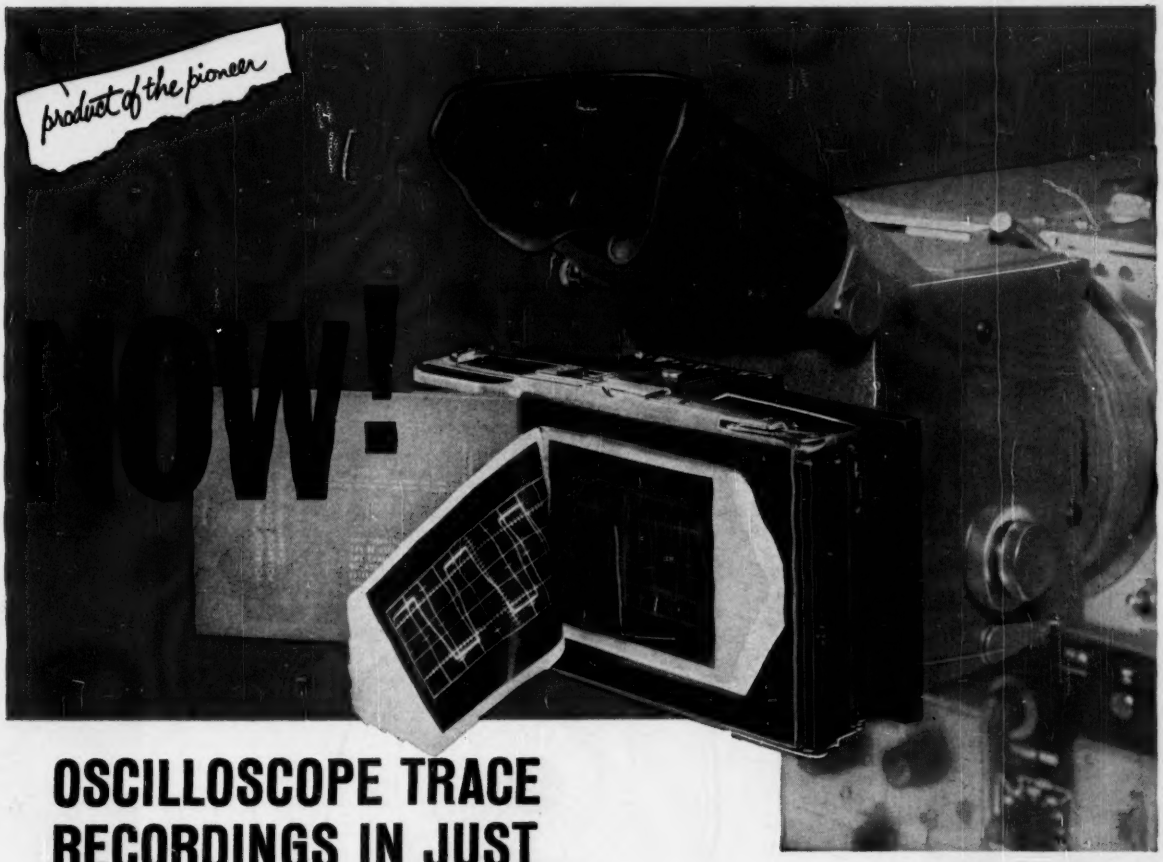


For application information write:

Bendix Computer Division
DEPT. J-28, LOS ANGELES 45, CALIFORNIA

THE Bendix CORPORATION

CIRCLE 28 ON READER-SERVICE CARD



OSCILLOSCOPE TRACE RECORDINGS IN JUST 10 SECONDS

Polaroid® by Polaroid Corporation

BY POLAROID AND DUMONT

WITH THE NEW DUMONT TYPE 450 CAMERA... PERMANENT RECORDS OF SCOPE DISPLAYS IN JUST 10 SECONDS

Almost as fast as readout, versatility extraordinary, permanence unequalled – this describes the new team of 10-second developing Polaroid Land 3000 speed film and the Du Mont Type 450 Recording Camera.

The new Polaroid Land film, with an ASA rating of 3200, gives you a permanent print *10 seconds* after you snap the shutter – and with resolution greater than ever before. Now you can record transients of nanosecond risetime speeds with complete clarity, and have prints available in instants.

Du Mont's most recent contribution to the scope camera field, the Type 450, provides such field-requested features as interchangeable lenses for image ratios from 1:1 to 4.5:1 – and interchangeable backs – to provide records in any size from 4" x 5" to 35 mm. All lenses are equipped with synchro shutters and external electrical connectors for tandem, automatic or remote operation. Mounting mechanisms have been greatly simplified, plus rack and pinion focusing, for additional speed in recording.

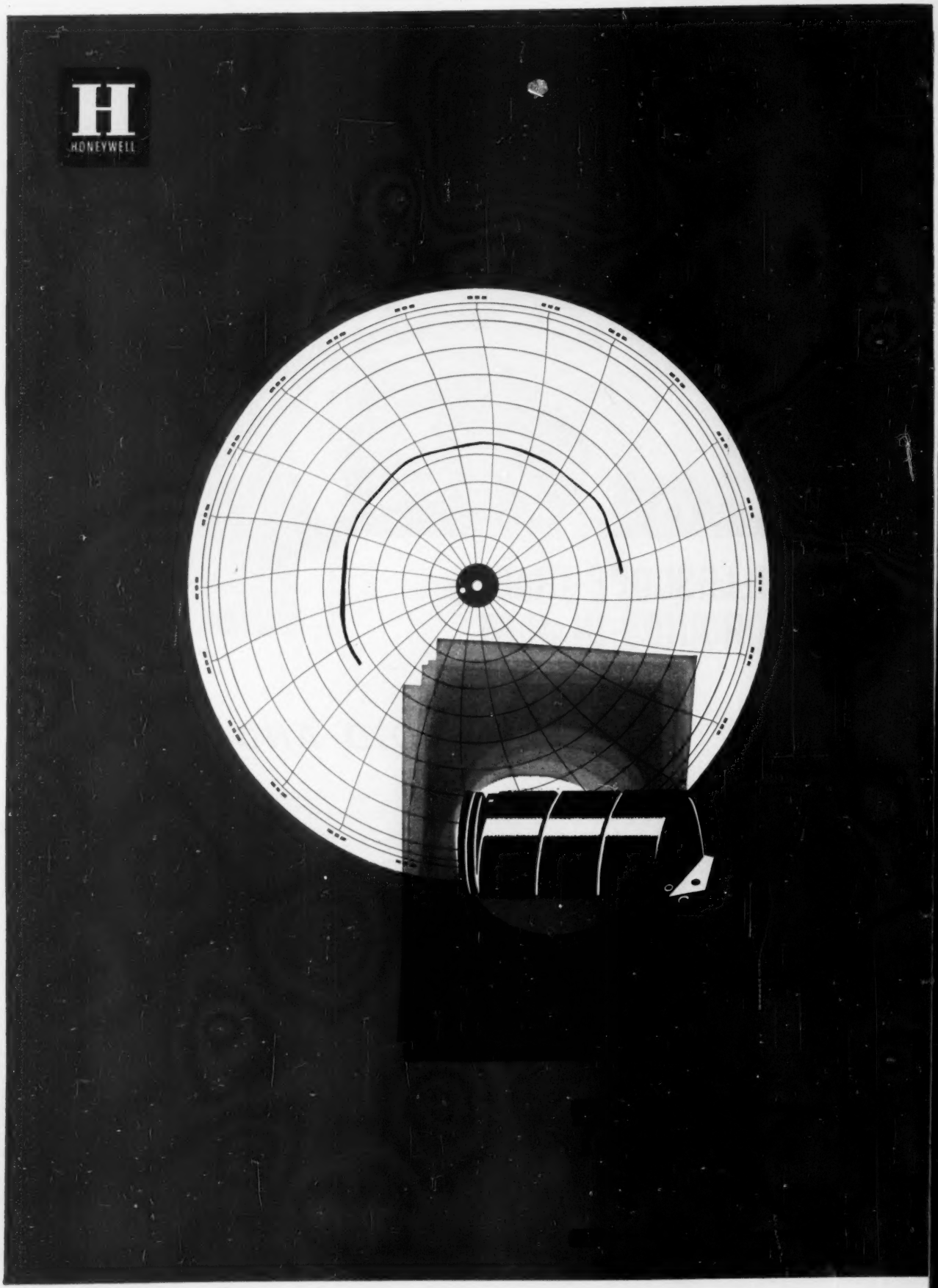
Write for complete details on obtaining records in 10 seconds – a new high in speed and versatility

DU MONT

ALLEN B. DU MONT LABORATORIES, Clifton, N. J.

DIVISIONS OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

CIRCLE 29 ON READER-SERVICE CARD


H
HONEYWELL

The New Honeywell Thermal System

withstands extreme vibration and corrosion conditions

Here's a new gas-actuated thermal system that takes the zig-and-zag out of temperature recording under severe vibration conditions.

A complete series of vibration tests has proved the vibration resistance of the new Class III thermal system. In these tests, the Class III system was installed in a standard Honeywell rectangular case recorder, and subjected to forced vibrations in three mutually perpendicular planes. With accelerations up to 0.2G from 0 to 200 cps, maximum pen oscillation was limited to 1.5%. For more than 75% of the range, *pen oscillation was less than 0.5%!* . . . with no resonant effects at 60 cycles.

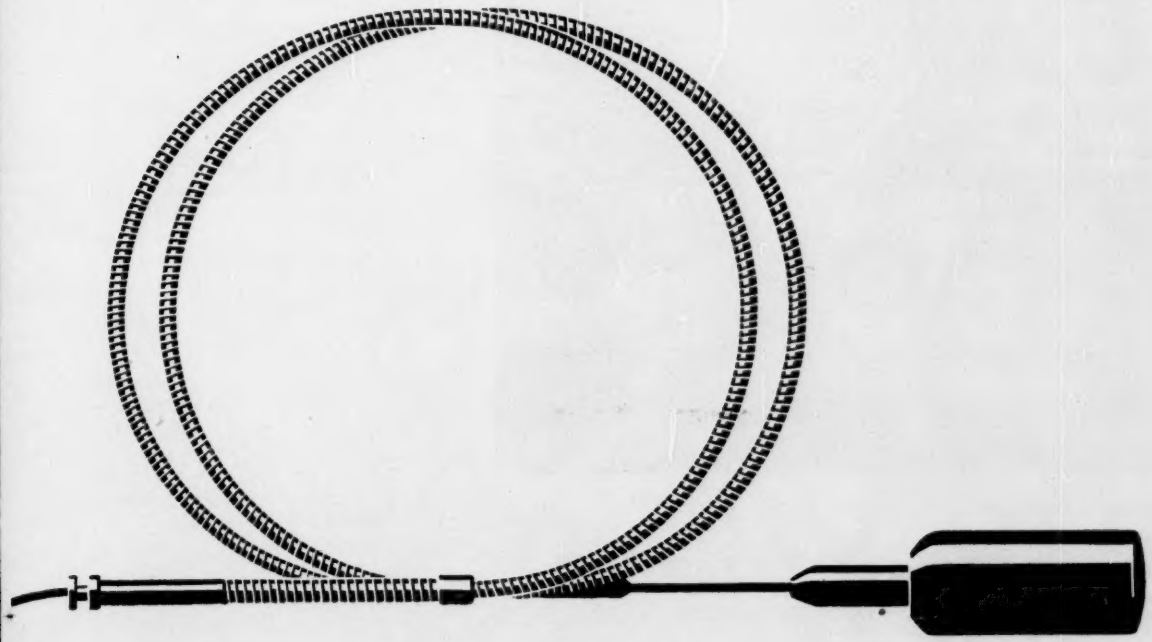
Check these many new design and construction features: high-energy helix for increased sensitivity and lower dead spot; built-in overrange or underrange protection; stainless steel bulbs to withstand corrosive atmospheres; low carbon 316 stainless steel linkages with low-friction, ball-joint construction; coarse and fine zero adjustments for easy settings.

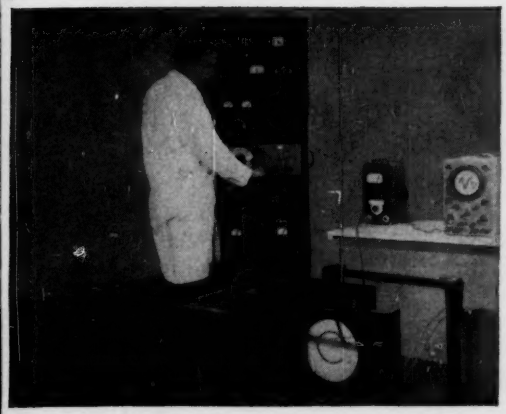
Get the complete story on the new Class III Thermal System by contacting your nearby Honeywell field engineer today. He's as near as your phone. MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pennsylvania.

Honeywell

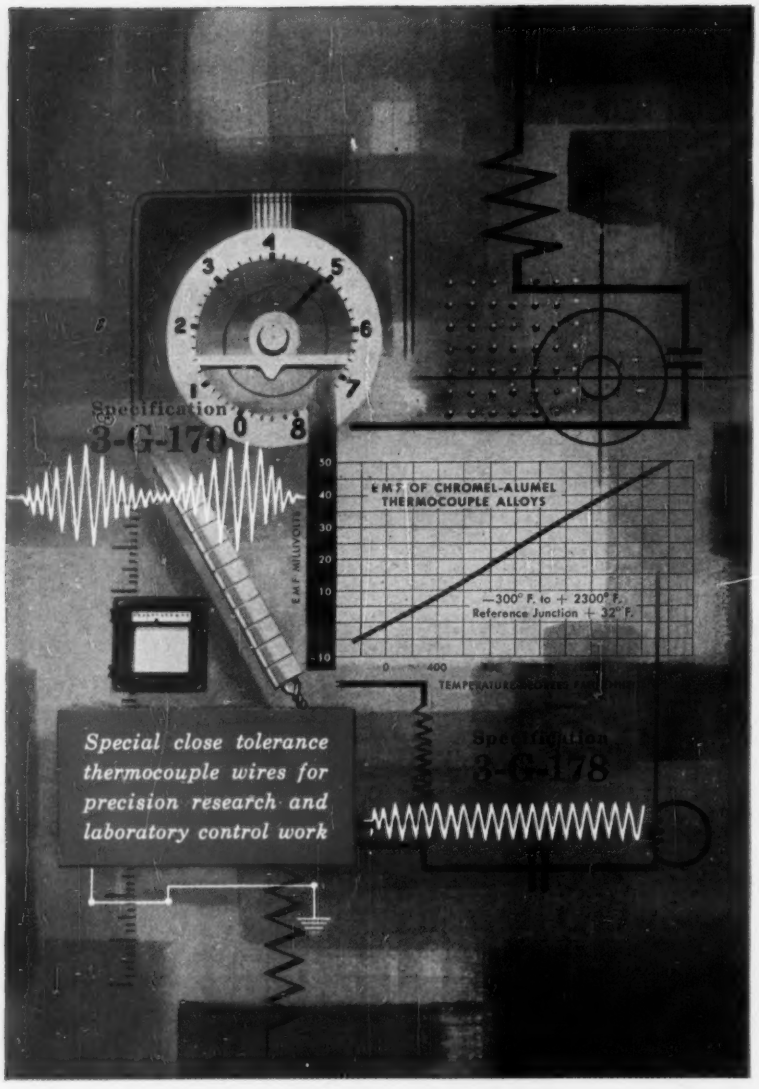
H HONEYWELL *First in Control*

SINCE 1885





CIRCLE 30 ON READER-SERVICE CARD



Chromel®-Alumel®*

THERMOCOUPLE ALLOYS

Hoskins Chromel-Alumel thermocouple alloys are the world's basic standard of accuracy for controlling the heat treatment of metals—the *only* base metal materials known having established and guaranteed temperature-emf characteristics over a useful operating range from −300° F. for cryogenic applications up to 2300° F. for measuring temperatures in industrial furnaces, nuclear reactors and jet aircraft engines.

Now, in addition to standard guaranteed millivoltage material, these extremely durable, ultra reliable alloys are also being produced in the following special grades for precision quality control:

Specification 3-G-178—Accuracy guaranteed to ½ standard tolerance limits.

Specification 3-G-170—Accuracy guaranteed within ±5° F. over temperature range from 1000° to 2000° F.

Available through instrument manufacturers, thermocouple fabricators, and pyrometer service companies. Write for complete technical data.

** Trade names you can trust for accurate temperature measurement!*

Genuine Chromel and Alumel are produced exclusively by

HOSKINS MANUFACTURING CO.

4447 Lawton Avenue • Detroit 8, Michigan

Custom-Quality resistance, resistor and thermo-electric alloys since 1908

CIRCLE 35 ON READER-SERVICE CARD

GUIDE ERRATA

In the process of streamlining and "automating" the procedures involved in producing our annual Buyers' Guide, some errors and omissions unfortunately occurred.

All recipients of the Guide are urged to note the following changes and to correct their copies of the 1961 edition (received as Part 2 of the November issue of INSTRUMENTS & CONTROL SYSTEMS).

In the Directory Section:

Representatives listed for Merit Coil & Transformer Corp. should have appeared under Merit Specialties Co.

Merit Specialties Co., Inc., 205 E. Davis St., St. Louis 11, Mo. VErnon 2-1706

REPRESENTATIVES

Okla., Kan., Nebr., Colo.
G. T. Cook Co., Midland Bldg.
Kansas City 5, Mo., VI. 2-9678

Ariz., New Mexico
Mr. Bruce Irwin, 3033 N. Central Ave.,
Phoenix, Ariz.

Miss., Ala., La., Ark., Tenn.
L. E. Offutt Co., 1492 S. Rozelle St.
Memphis, Tenn., BR 4-0235

Texas
Mr. John A. West, 1230 S. Montreal
Dallas 8, Tex. FE. 1-6970

Indiana
Hayden, Quinn & Pollard, 618 Wysor Bldg.,
Muncie, Ind., AT. 4-1691

Pantex Valve Actuators, P. O. Box 22351, Houston 27, Texas, MOhawk 6-0386 should be inserted, and the listing for Pantex Mfg. Corp. should be removed.

Listing for Texas Div., Clevite Corp. should be removed.

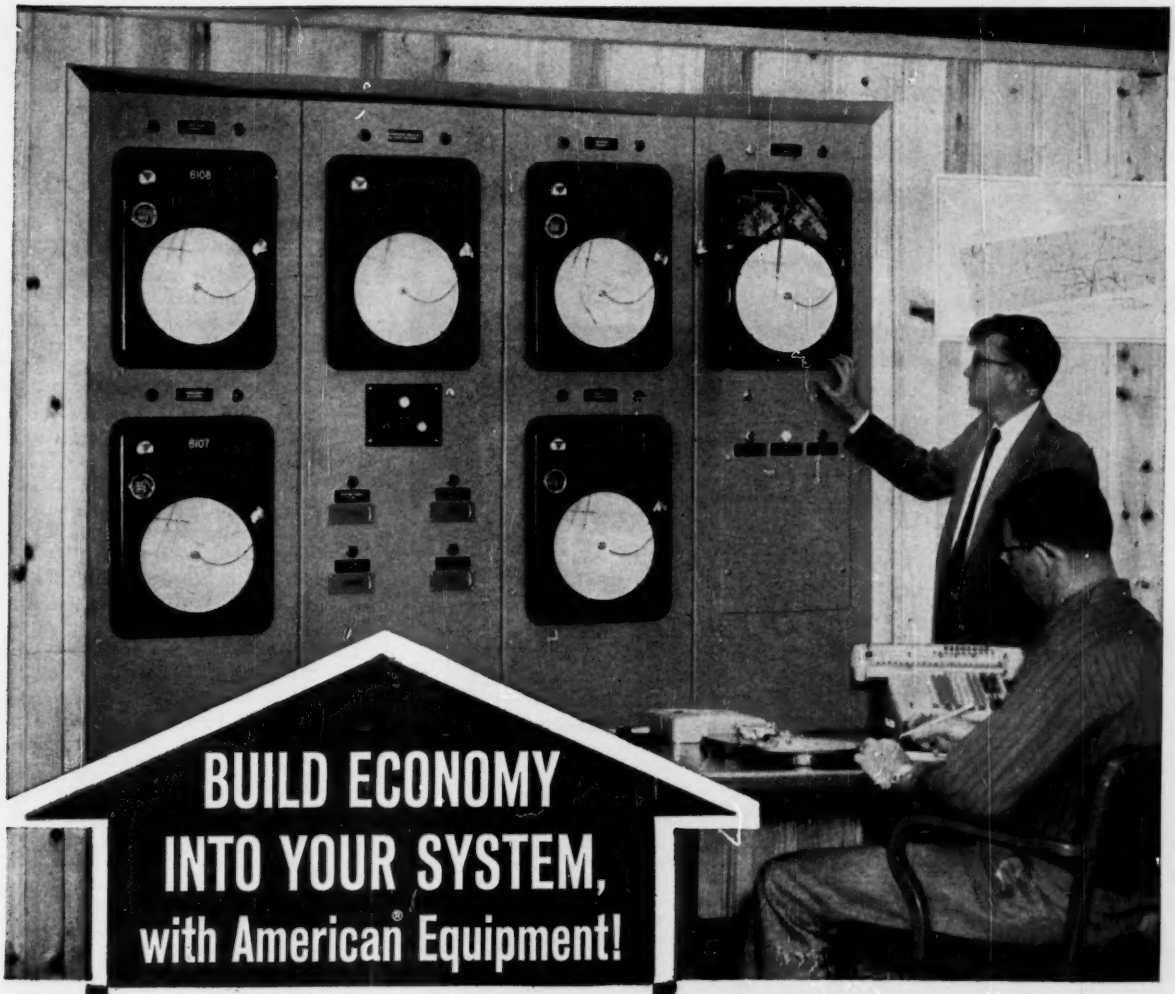
Texas Instruments, Inc. address shown was that of the Semiconductor-Components Div. The Geosciences & Instrumentation Div. address, 3609 Buffalo Speedway, Houston 6, Texas, JAckson 6-1411, should be inserted, also.

In the Catalog Sections, make the following insertions for the companies indicated:

Tri-R Instruments. Insert in Catalog 1, under: TEMPERATURE CONTROLLERS & REGULATORS; and under THERMOMETERS, THERMISTOR. In Catalog 4, under MEDICAL INSTRUMENTS & EQUIPMENT, including Electromedical; and under STIRRERS, Laboratory, Variable Speed.

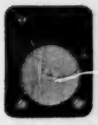
Sensitive Research Instrument Corp. In Catalog 1, add under: PYROMETERS, Millivoltmetric; PYROMETERS, Potentiometric; PYROMETERS, Thermo-electric. In Catalog 3, add under: AMMETERS, AC and/or DC; AMMETERS, Microammeters

Continued on page 40



BUILD ECONOMY INTO YOUR SYSTEM, with American® Equipment!

If you're already using American measurement and control equipment on your system — large or small — you know how it reduces manpower requirements and provides continuous operating economies. If you're not already saving with American equipment, ask your representative for full information. You'll be surprised to learn how little it costs to build sustained accuracy, dependability and long-term operating economies into your system.



TELEMETERING SYSTEMS — Designed to meet the individual requirements of any system.

CONTROLLERS — Series A-88 Controllers, Transmitters and Receivers for measurement and control of continuous process variables.

ORIFICE METERS — Dri-flo and mercury manometers in recording, indicating and integrating models — in a variety of working pressures and differential ranges.

CANNON PENS — Record up to a year without refilling — produce charts of maximum legibility — no blurring or smearing.

RELIANCE REGULATORS — For industrial, commercial and house service applications.

AMERICAN METER CO. EST. 1836

AMERICAN® METER COMPANY

INCORPORATED (ESTABLISHED 1836)

GEM MEMBER GAS EQUIPMENT MANUFACTURERS GROUP

GENERAL SALES OFFICE: Philadelphia 16, Penna. • Albany • Alhambra • Atlanta • Baltimore • Birmingham • Boston • Chicago • Dallas • Denver • Erie • Houston • Kansas City Los Angeles • Minneapolis • New York • Omaha • Pittsburgh • San Francisco • Seattle • Tulsa • Wynnewood

IN CANADA: Canadian Meter Company, Ltd., Milton, Ontario • Calgary • Edmonton • Montreal • Regina • Vancouver

SUPPLIERS TO THE GAS INDUSTRY for Ironcase, Tinned Steelcase, Aluminumcase, and Welded Steelcase Meters • American-Westcott Orifice Meters • Instruments • Reliance Regulators • Apparatus • Valves

CIRCLE 31 ON READER-SERVICE CARD

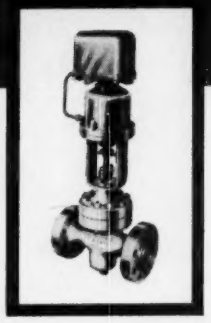
GENERAL KINETICS
DE VAR

NOW AVAILABLE

NEW LOW PRICED

P-K PAUL CONTROL VALVES

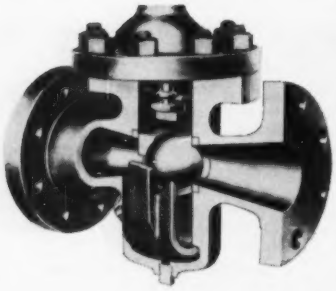
The new Series G
is priced competitively
with conventional control valves



The same unique design that made the P-K Paul Venturi Control Valve the most efficient throttling control valve ever devised **for critical applications** has been incorporated into the new Series G line of P-K Paul Control Valves.

IN ADDITION TO *LOWER COST*

You Get:



- **Higher Flow Capacity**
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CIRCLE 32 ON READER-SERVICE CARD

Continued from page 38

and Milliameters; AUDIO-FREQUENCY EQUIPMENT; CIRCUIT ANALYZERS; ELECTRICAL INSTRUMENT CALIBRATORS; FIELD-STRENGTH MEASURING SETS; FREQUENCY INDICATORS; GALVANOMETERS, AC; KVA INDICATORS; LINE CURRENT TEST SETS; LOAD INDICATORS; MAGNET TESTERS; MAGNETIC FIELD-STRENGTH INDICATORS; MULTIPLIERS; PERMEAMETERS; POTENTIOMETERS, Manually-balanced; POWER FACTOR INSTRUMENTS; SHUNTS; VOLTAGE, HIGH (above 2300 volts), MEASURING DEVICES; VOLT-AMMETERS; VOLT-AMPERE METERS, Reactive; VOLTMETERS, Electrostatic; VOLTMETERS, Indicating and Recording; VOLTMETERS, Laboratory Standard; VOLTMETERS, Micro (etc.); VOLTMETERS, Millivoltmeters, AC, Rectifier; VOLTMETERS, Oxide Rectifier; VOLTMETERS, Peak; VOLTMETERS, Thermo; WATTMETERS, Indicating; WATTMETERS, Laboratory Standard; WATTMETERS, Reactive; X-RAY VOLTMETERS, High Potential. In Catalog 4, add under ELECTROLYSIS INSTRUMENTS. In Catalog 5, add under AIRCRAFT INSTRUMENT TESTERS, and under FLIGHT TEST INSTRUMENTS. In Catalog 8, add under GALVANOMETER MOVEMENTS; MAGNETS, Permanent; POINTER STOPS; POINTERS, Instrument; SCALES, Instrument; STANDARD CELLS; and under THERMOCOUPLES, Vacuum.

IGS EVENTS

January 31-February 2
Eighth Annual Cleveland Electronics Conference, Cleveland Engineering & Scientific Center. For information write Lapine Enterprises, 310 Hotel Manger, Cleveland 14, Ohio.

February 2-4
6th Annual ISA North Central Area Automation Symposium, Radisson Hotel, Minneapolis, Minn. For information contact, Mr. Howard Marston, Honeywell, 621, E. Honnepin Ave., Minneapolis.

BOOKS

For more information on these books, or for publisher's book list circle number on reader-service card.

Dictionary of Automatic Control by Robert J. Bribbero, [c 1960] Reinhold Publishing Company, 430 Park Ave., New York 22, N. Y. 282 pp., 7½", cloth-bound $6.00. This encyclopedic dictionary contains more than 500 expanded definitions of automatic control terms. A classified index contains a breakdown into five subjects which assists the reader in finding a similar term or concept.

Engineering Thermodynamics by Newman A. Hall and Warren E. Ibele, [c 1960] Prentice-Hall, Inc., Englewood Cliffs, N. J., 643 pp., 9", clothbound $10.50. A comprehensive treatment of thermodynamics analysis from the engineering viewpoint; combines critical evaluation of principles with practical applications, pioneering new concepts.

Semiconductor Digest, published by Systematic Programing & Editing Co., 3604 Woodland, Kansas City, Mo., 346 pp., 9", ring-binder $12.50. Consists of specifications on diodes, rectifiers, variable capacitors of twenty-seven major manufacturers.

Control Systems Engineering edited by William W. Seifert and Carl W. Steeg, Jr., [c 1960] McGraw Hill Book Company, Inc., 330 West & 42nd St., New York 36, N. Y., 964 pp., 10", clothbound $15.00. This volume in the Electrical and Electronic Engineering Series offers a relatively complete coverage of the mathematical aspects of modern control systems engineering. Thirteen out of the fifteen chapters are devoted to a systematic development of the theoretical techniques used in the analysis and synthesis of control systems.

Mercury Barometers and Manometers, by W. G. Brombacher, D. P. Johnson, and J. L. Cross, National Bureau of Standards Monograph 8, 59 pp., 10¼", 40 cents. Order from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Monograph describes the various designs of mercury barometers and manometers, sources of error, methods of minimizing these errors and of making corrections. Includes extensive tables.

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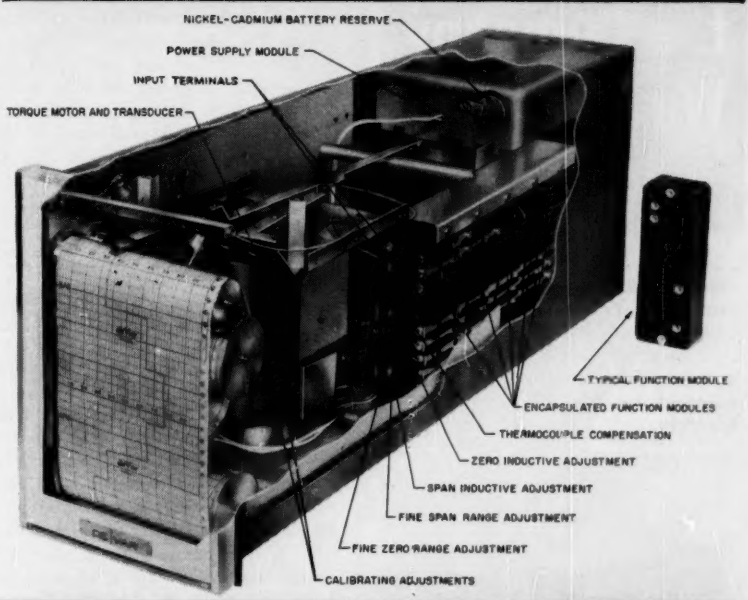

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CIRCLE 33 ON READER-SERVICE CARD

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ENJAY
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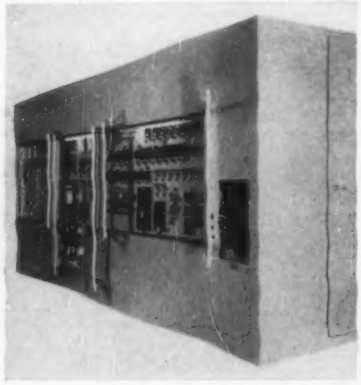
Judging by the Company We Keep...
Electro-Mech

. . . The Company We Keep have many names, one standard: all are perfectionists. For Custom Control Centers, they frequently call on us . . . we're perfectionists too! Won't you join "The Company We Keep?" Contact us for all your Control Centers.



The Electro-Mech panel shown above controls a large water conditioning system. It has over 3000 relay contacts and 13,000 feet of wire. Electro-Mech excellence of design and meticulous craftsmanship, which makes possible the flawless operation of systems such as this, are hallmarks of perfectionists.
Allow us to submit a proposal on your control system needs.

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Electro-Mech

CIRCLE 34 ON READER-SERVICE CARD

ICS PANHANDLE PETE

The Rugged Individual

It seems a young man lived with his parents in a public housing development. He attended public school, rode the free school bus, and participated in the free lunch program. He entered the Army and upon discharge kept his national life insurance. He then enrolled in the state university working part time in the state capital to supplement his GI check.

Upon graduation, he married a public health nurse and bought a farm with an FHA loan and then obtained a Small Business Administration loan to go into business. A baby was born in the county hospital. He bought a ranch with the aid of a GI loan and obtained emergency feed from the government.

Later he put part of his land in the soil bank and the payments helped pay off his debt. His parents lived comfortably on the ranch with their social security and old-age assistance checks. REA lines supplied electricity. The Government helped clear the land. The county agent showed him how to terrace it, then the Government paid part of the cost of a pond and stocked it with fish. The Government guaranteed him a sale for his farm products.

Books from the public library were delivered to his door. He banked money which a government agency insured. His children grew up, entered public school, ate free lunches, rode free buses, played in public parks and swam in the public pools. The man owned an automobile which he enjoyed riding on federal-aid highway-program highways. His farming business used great amounts of second and third class government-subsidized mail.

He signed a petition seeking federal assistance in developing an industrial project to help the economy of his area. He was a leader in obtaining a new federal building and a new postoffice for his city, and went to Washington with a group to ask Congress to build a great dam costing millions so that his area could get cheap electricity.

Then, one day, at election time, he wrote to his congressman:

"I wish to protest excessive government spending and high taxes. I believe in rugged individualism. I think people should stand on their own two feet without expecting government handouts. I am opposed to all socialistic trends, and I demand a return to the principles of our Constitution."

Panhandle Pete

Thanks to Rotary Magazine and Western Gear Corp's. *High Gear*, Nov. 6, 1960.

***Electronic Circuitry for* Instruments and Equipment**

by M. H. Aronson. "Comprehensive source book on instrument circuitry" this complete home-study text includes 458 multiple-choice questions (and answers). 215 illustrations. 10 tables, comprehensive index. *Paperbound, 324 pages, 1957 (revised edition).* **$2.00**

100 Electronic Circuits

by M. H. Aronson and C. F. Kezer . . . covers amplifiers, oscillators, pulse circuits, phase shifters, etc. Complete with all circuit component values and response specifications. *Paper, 180 pages, 1957.* Vol. 1 ..... **$2.00** Vol. 2 ..... **$2**

Strain Gage Instrumentation

edited by Aronson and Nelson. ". . . a *practical text . . . covers fundamentals,* basic bridge circuits, typical applications, and surveys, typical commercial instruments which use or are used with strain gages." Paper, 110 pages, illustrated, indexed by company, author, and subject, 1958. ..... **$2.00**

Control Valves

by C. S. Beard. New "one-book" reference on control valves . . . covers flow characteristics; mechanical features; valve capacity; sizing; body types; positioners; actuators, including d-c, electrohydraulic and gas hydraulic actuators. Numerous tables and illustrations. *Paperbound, 236 pages, 1957.* **$2.00**

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You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save *the cost of maintaining these devices. You can greatly* reduce instrument maintenance costs. For the Nash em*ploys no internal lubrication, therefore no troublesome* oil is in the delivered air. Moreover, air from a Nash *is thoroughly washed and cooled as it passes thru the* pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to *contaminate air handled.*
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
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Sub-Min. Widest selection of Pilot Lights -from DIALCO

T-2

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HIGH BRIGHTNESS and REGULAR TYPES

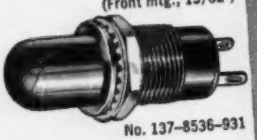
DIALCO's Sub-Miniatures use tiny T-2 Neon Glow Lamps: *NE-2J (High Brightness)* at 105-125 V., A.C.; or *NE-2D* (regular) at 105-125 V., A.C. or D.C.

NEW Series mounts from *FRONT* of panel in 15/32" clearance hole (supplements 17/32" Series). Also—units for mounting from *BACK* of panel in 15/32" clearance hole. Unique lenses in 5 colors; give all-angle visibility. Units are fully insulated; meet applicable Mil. Specs.

Ask for Brochures L-159B and L-162.

(Illust. approx. actual size)

(Front mtg., 15/32")



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INCANDESCENT
2-TERMINAL and 1-TERMINAL TYPES

Designed for use with T-1¾ midget flanged incandescent lamps—1.3 V. to 28 V... *NEW* Series mounts from *FRONT* of panel in 15/32" clearance hole—(supplements 17/32" Series). Also—units for mounting from *BACK* of panel in 15/32" clearance hole. Unique lenses in 7 colors. Units are fully insulated; meet applicable Mil. Specs.

Ask for Brochures L-156C thru 159B, and L-162.

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Spring-mounted Lens-with-Message is *rotatable*.

1-Terminal Pilot Lights

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SAMPLES ON REQUEST—AT ONCE—NO CHARGE

Foremost Manufacturer of Pilot Lights

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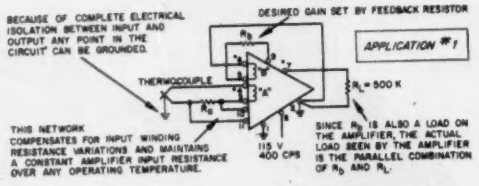
CIRCLE 36 ON READER-SERVICE CARD

ICS **BRIEFS**

Low-Level Magnetic Amplifiers

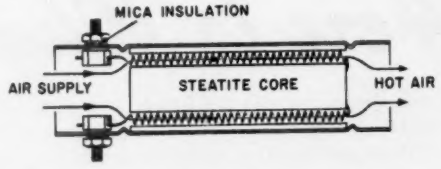

BECAUSE OF COMPLETE ELECTRICAL ISOLATION BETWEEN INPUT AND OUTPUT ANY POINT IN THE CIRCUIT CAN BE GROUNDED.
DESIRED GAIN SET BY FEEDBACK RESISTOR
APPLICATION #1
THERMOCOUPLE
R_L = 500 K
THIS NETWORK COMPENSATES FOR INPUT WINDING RESISTANCE VARIATIONS AND MAINTAINS A CONSTANT AMPLIFIER INPUT RESISTANCE OVER ANY OPERATING TEMPERATURE.
115 V 400 CPS
SINCE R_b IS ALSO A LOAD ON THE AMPLIFIER, THE ACTUAL LOAD SEEN BY THE AMPLIFIER IS THE PARALLEL COMBINATION OF R_b AND R_L.

Series 5800 PREAC magnetic amplifiers feature null stabilities of 28 mv or less over a temperature environment of —40° to 85°C as shown in Application 1 . . . Problem: A 20 ohm thermocouple source yields a full scale output of 10.25 mv. An output of 5v dc into a 500K load is required to drive a voltage controlled oscillator in a telemetering application. The environmental temperature extremes are —40° to 85°C. Solution: 1) Type M-5849-C is chosen because of the low source impedance; 2) 21 ohms is selected for R_a (from included table); 3) 55K is chosen for R_b to obtain the desired gain. This is determined from the notes or experimentally . . . (*From 2-page Bulletin M-88, Airpax Electronics Inc., Seminole Div., Fort Lauderdale, Fla.*)

FOR THIS LITERATURE CIRCLE 169 ON READER-SERVICE CARD

Heating Wattage Data

The following formulae can be employed in determining wattage capacity required for heating different materials:



(a) Watts required for heat-up =

$$\frac{\text{Weight of material (lbs)} \times \text{specific heat} \times \text{temperature rise °F}}{3.412 \times \text{time (hours or fraction thereof)}}$$

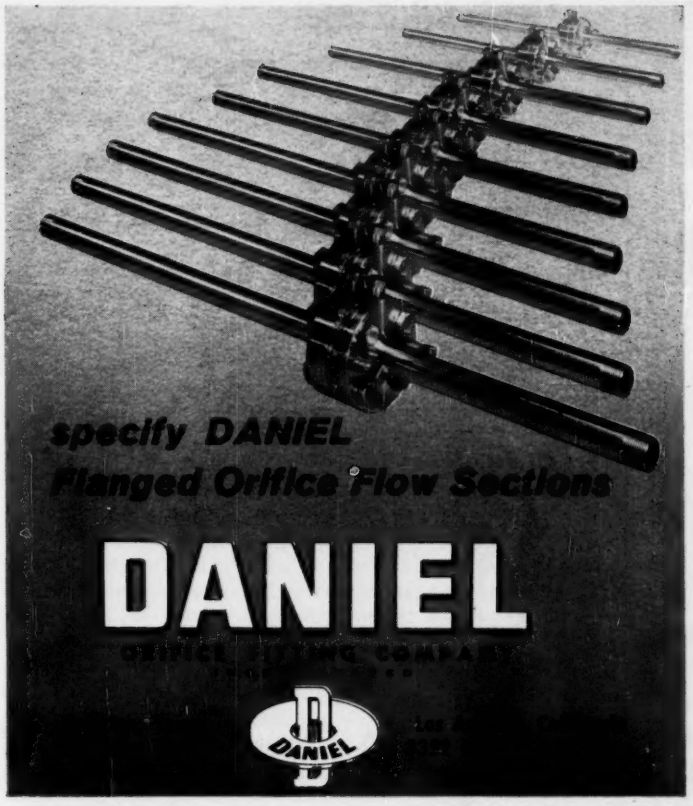
(b) Watts heat losses at operating temperatures = Watts loss/sq. ft. (curves given) × area in sq. ft.

(c) Watts for melting or vaporizing =

$$\frac{\text{Wt. of material (lbs)} \times \text{heat of fusion or vaporization (Btu/lb)}}{3.412 \times \text{heat-up time (hours or fraction thereof)}}$$

(*From 12- page bulletin, Hotwatt, Inc., 75 Maple St., Danvers, Mass.*)

FOR THIS LITERATURE CIRCLE 170 ON READER-SERVICE CARD



solve the BIG problem in small flow measurement

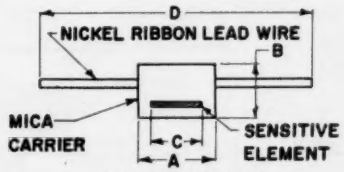
Metering small flows in test labs, pilot plants and research centers with Daniel honed flow sections gives you the edge in accuracy. How? Because Daniel flow sections *give reliable duplication of performance* to overcome a big problem in small flow measurement. Each unit is manufactured just like the previous one to report the most accurate signal on any make differential recorder or indicator.

Inside diameters of each unit are honed to plus or minus .001" tolerances. Materials available . . . carbon and 316 stainless steel, others on request. Operating pressures from 0 to 1440 P.S.I. (Gage) C.W.P., 600 lbs. A.S.A. or higher. Sizes . . . ¼", ½", ¾" and 1-inch. Send for your copy of Daniel catalog section "O".

CIRCLE 37 ON READER-SERVICE CARD

Semiconductor Strain Gages

New Kulite gages provide all the desirable characteristics of conventional strain gages and strain gage devices, but are more versatile and provide significantly higher outputs . . . Their strain-sensitive element



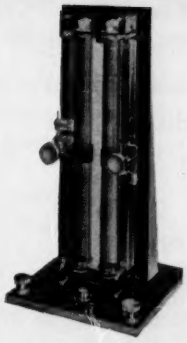
DA AND DAN SERIES

consists of a filament sliced from a single semiconductor crystal . . . grown with a controlled impurity content to obtain various characteristics . . . They employ the piezoresistance effect, defined as the change in electrical resistivity with applied stress . . . In certain semiconductors the effect is very large, and appreciable changes in resistivity occur with applied stress. This effect is not to be confused with the piezoelectric effect . . . Metal wire and foil gages have factors between 2 and 4. Kulite gages have factors between 50 and 200 . . . In the same physical geometry, the resistance of the gage can be varied by more than 1000 to 1 and the gage factor can be carried from minus 100 to plus 200. (*From* 4-*page Bulletin* K-101, *Kulite-Bytrex Corp.*, 50 *Hunt St., Newton* 58, *Mass.*)

FOR THIS LITERATURE CIRCLE 171 ON READER-SERVICE CARD

NOW! PRECISION AT LOW COST!

NIL TYPE M-12 PRECISION MANOMETER



The versatile micromanometer which can be operated at high working pressures. A simple U-tube with vernier readers makes it possible to offer this exclusive combination of features:

- 150 PSIG maximum working pressure.
- ± 0.001 inch sensitivity.
- Water or mercury can be used.
- Forward or reverse use without changing connections.
- Range −9 to +11 inches.

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CIRCLE 38 ON READER-SERVICE CARD

EPLAB

PYRHELIOMETER
For the Measurement of SOLAR RADIATION

Eppley Pyrheliometers are used for solar radiation measurements at ninety-eight weather stations in the continental United States, Canada, Alaska, Greenland, Iceland, Caribbean Sea, and the Pacific Ocean. Sixty-two of these stations are under the direction of the United States Weather Bureau.

The Eppley Pyrheliometer was adopted as standard equipment by the Weather Bureau after considerable experimentation. It was found to be the best instrument so far tested by the Bureau.

Used in conjunction with a suitable recorder, the Eppley Pyrheliometer will provide an accurate and reliable record of total solar and sky radiation on a horizontal surface.

Bulletin No. 2 on Request

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Scientific Instruments

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Newport, Rhode Island U. S. A.

CIRCLE 39 ON READER-SERVICE CARD

Why Air Cargo?

Three reasons for using air cargo: 1) To keep production moving by minimizing costly, time-consuming interruptions and by getting replacement parts fast;

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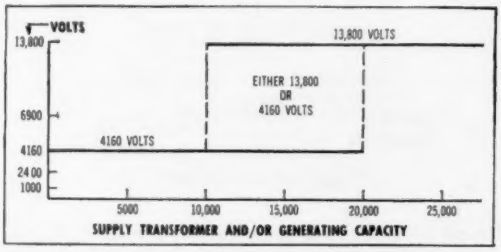
8002—SCIENTIFIC, PRECISION, DENTAL AND SURGICAL INSTRUMENTS, AND PARTS THEREOF, NES, EXCL. WATCHES AND CLOCKS			
AMSTERDAM	.37	100	28
ANTWERP	.37	100	28
BASLE	.37	100	26
BELFAST, G.BR.	.37	100	31
BERGEN	.42	100	30
BERLIN	.38	100	26
BIRMINGHAM, G.BR.	.37	100	30
BREMEN	.37	100	26
BRUSSELS	.37	100	28
COLOGNE	.37	100	27
COPENHAGEN	.37	100	26

2) To replace fast turnover items quickly and to meet unexpected demands; 3) To save packing weight and crating time. For example, 3000-lb equipments are wrapped with protecting cloth, then mounted on standard equipment for shipping . . . Interline agreements with world air-carriers permit goods to be shipped as fast as possible to *any destination* wanted . . . Reproduced table is section of commodity rates for scientific and precision instruments . . . (*From* 2- *page and* 12-*page leaflets and* 34- *page General and Specific Commodity Rates, KLM Royal Dutch Airlines,* 430 *Park Ave., New York, N. Y.*)

FOR THIS LITERATURE CIRCLE 172 ON READER-SERVICE CARD

How To Pick the Best Voltages

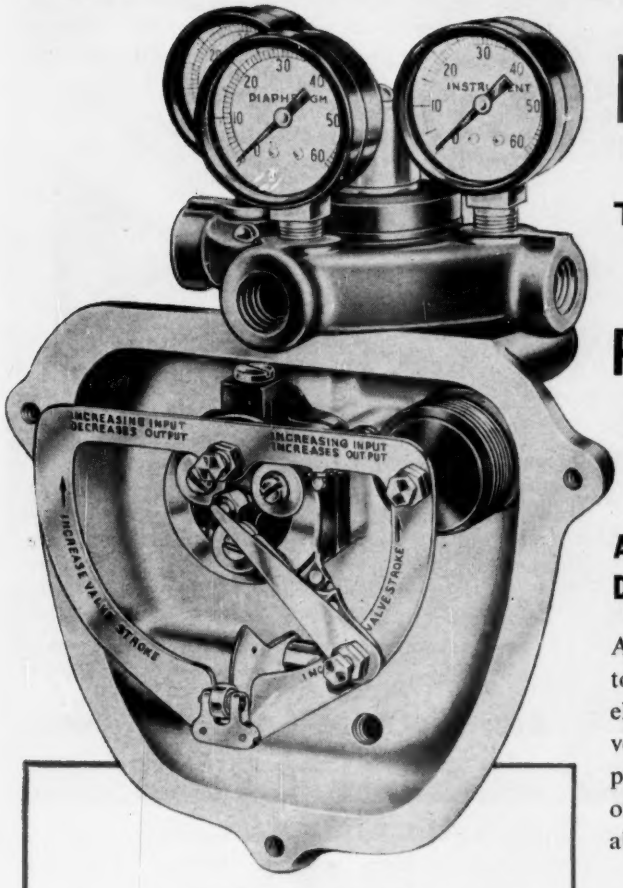
There's a bewildering array of voltages in common use in industry. Picking the voltage levels for your plant is worth doing right.



600 vs 480 volts—Immediate attraction of a 600-volt system: It costs between 2% and 7% less than a 480-volt system. Only problem: Most motorized equipment is not readily available at 550 volts. So unless you face some special situation (e.g., a great deal of textile machinery is equipped, as standard, with 550-volt motors), 440-volt motors—and thus a 480-volt system—are an obvious choice over the 600-volt system.—(*From* 48-*page GEA*-7139, *"Better Power for Production" with sections on How to Start Planning a Better Electrical System, All You Need to Know about Relays, Your Best Secondary System . . . General Electric Co., Schenectady* 5, *N. Y.*)

FOR THIS LITERATURE CIRCLE 173 ON READER-SERVICE CARD

A new concept in design makes possible the...



FISHER

TYPE 3560 VALVE POSITIONER

V/P

Assured product performance through DYNAMIC ANALYSIS engineering

Application of mathematical techniques of design to pressure control systems has enabled Fisher to eliminate the conventional approach in the development of the new V/P valve positioner. It has provided the V/P with the following combination of characteristics and performance . . . unobtainable in any other type of valve positioner.

SMALL AND COMPACT . . . only 6⅜" wide and 8¾" high (with gauges).

CONVENIENT ADJUSTMENT . . . valve stroke and zero adjustment readily accessible and easy to make.

SPLIT RANGE . . . no parts change whatsoever is required for split range operation.

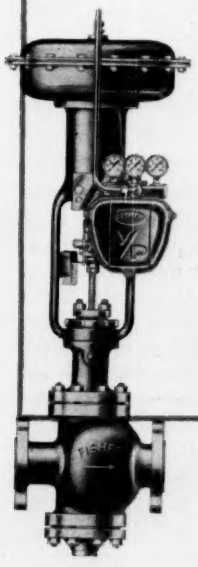
EASILY REVERSIBLE . . . reversed by simply moving flapper arm from one beam quadrant to the opposite quadrant.

CHARACTERIZED CAMS . . . offer wide flexibility in valve characteristics.

PERFORMANCE DATA

Hysteresis, (Average)	0.0012"
Linearity	as required. Change cams to obtain desired characteristics
Sensitivity	0.14 psi
Resolution Sensitivity	0.002 psi
Repeatability	±0.0003"
Stroking Speed	0.37 in/sec.
Air Consumption	10 scfh
Break Frequency (5% of instrument pressure range)	3.9 cps
Break Frequency (3% of instrument pressure range)	4.6 cps

The above performance data was taken from laboratory tests on a Type 657 diaphragm actuator, Size 40, with 1½" travel. Instrument range 3 to 15 psi.



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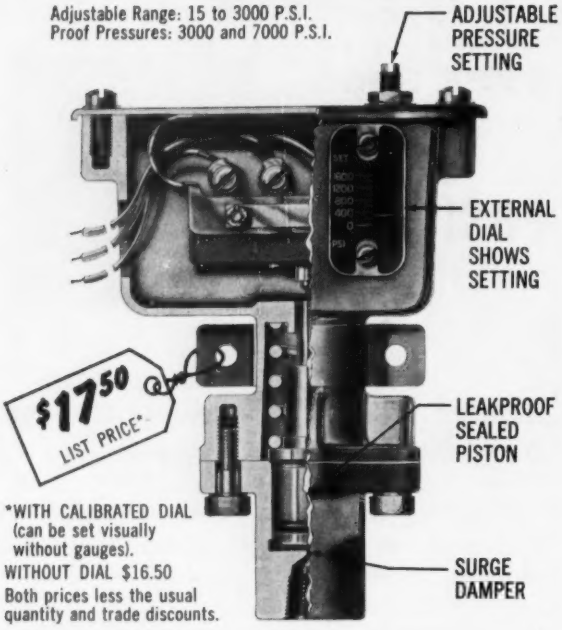
CIRCLE 40 ON READER-SERVICE CARD

ONLY
This Pressure Switch
Resists 7000 p.s.i. Surges
and Stays Accurate within 2%



*WITH CALIBRATED DIAL (can be set visually without gauges).
WITHOUT DIAL $16.50
Both prices less the usual quantity and trade discounts.

WE BUILD IN	WE DON'T USE
RUGGEDNESS CAN TAKE SURGES (High proof pressures) CONTINUOUS OPERATION (Millions of cycles) NO STICKING (in dirty fluid)	LINKAGES & BEARINGS WHICH WEAR QUICKLY (cause settings to drift and switch to fail).
LABOR & MATERIAL SAVINGS NO RETURN DRAIN PIPING (Sealed piston) MOUNTS WHERE CONVENIENT (Operates in any position, not sensitive to vibration)	UNSEALED PISTONS WHICH ADD TO YOUR INSTALLATION COST (return piping). ARE CRITICAL TO DIRT (pistons get stuck).

Send for FREE catalog

PRESSURE SWITCH DIVISION

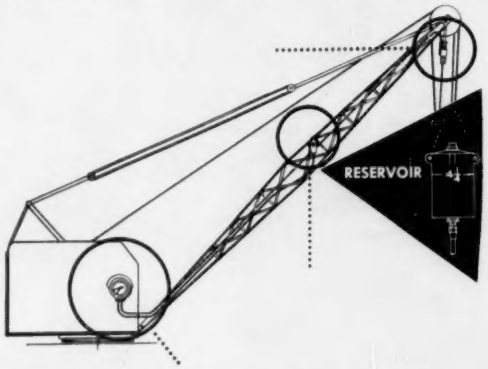
Barksdale valves

5125 Alcoa Avenue, Los Angeles 58, California

CIRCLE 41 ON READER-SERVICE CARD

Crane Weight-Indicator

New Type SB-10 Crane Weight-Indicator shows three readings at one glance: boom radius at which crane is operating, crane capacity at that radius, and

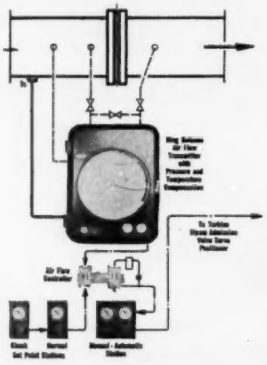


weight being lifted . . . It is made up of two systems—a hydraulic pressure transformer, high-pressure hose and indicating gauge; and a fluid reservoir, low pressure hose and indicating gauge. Both indications are combined in a single gauge . . . (*From* 4-*page Bulletin M*-39, *Martin-Decker Corp.*, 3431 *Cherry Ave., Long Beach* 7, *Calif.*)

FOR THIS LITERATURE CIRCLE 174 ON READER-SERVICE CARD

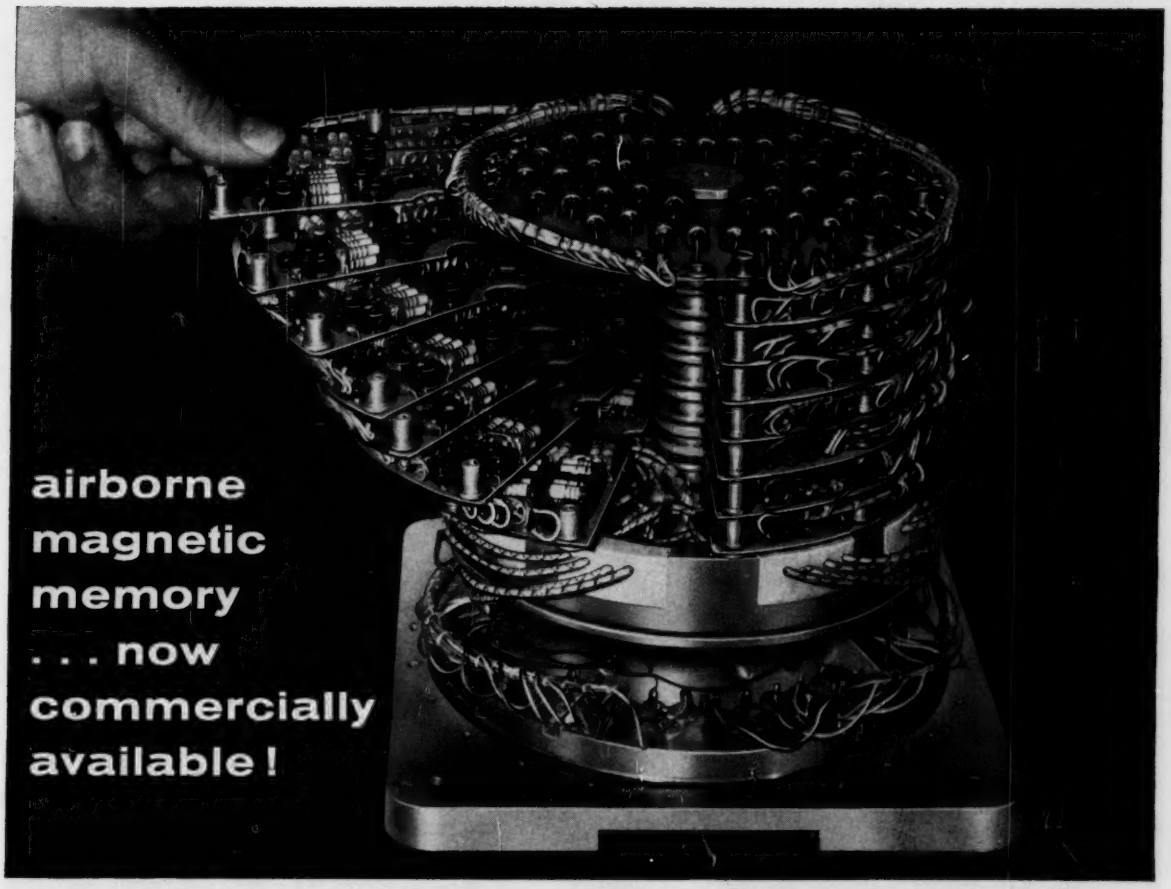
Blast Furnace Control Systems

On a tonnage basis, the largest single ingredient entering the blast furnace reaction is air . . .



The automatic, continuous pressure-and-temperature-compensated . . . Hagan Ring Balance Air Flow recorder-transmitter . . . provides a pneumatic signal which is linearly proportional to true weight or scfh of air. The flow controller compares the air flow signal with a manually adjustable pneumatic set point signal. It determines the magnitude and direction of the error between set point and flow and the time the error existed, and from these it continuously computes the turbine steam admission valve position required to reduce the error to zero; that is, to match the flow to the set point . . . Once set, flow is held constant except for checks and casts . . . (*From* 24-*page Bulletin MSA*-190, *Controls Div., Hagan Chemicals & Controls, Inc., Hagan Center, Pittsburgh* 30, *Pa.*)

FOR THIS LITERATURE CIRCLE 175 ON READER-SERVICE CARD



New LFE Bernoulli Disk Data Storage Device weighs 6 pounds* . . . operates on 12 watts . . . resists 30g shock!

Originally developed for reliable storage and retrieval of data in outer space, this miniaturized unit introduces the BD-40 Series of customized LFE Bernoulli Magnetic Disk Memories . . . the simplest rotating storage devices ever developed.

These space-and-weight-saving units store data on a flexible magnetic disk. Their read/write accuracy under extreme shock and vibration conditions is maintained by a balance of forces generated by fluid flow together with centrifugal and curvature forces in the disk.

Compatible with all EDP systems requiring storage of information on a magnetic surface, the BD-40 Series combines the advantages of minimum size, weight, and power with ultimate reliability and immunity to adverse operating environments. Available with or without electronic circuits. For complete information, write for Technical Data Brochure.

TYPICAL SPECIFICATIONS BD-40 SERIES	
Dimensions — Inches	
Height	4
With Electronics	7
Mounting Flange	7.25 x 7.25
Weight — Pounds	
*Without Electronic Package	6
With Electronic Package	10
Power Requirements — Watts (approx.)	
Motor Drive (115v, 400 cps, 3 phase)	12
Electronics (+5, −5, +10, +15v D.C.)	3 non-recording
Environmental	
Temperature-operating	0° to 85°C
non operating	−60° to 125°C
Shock	30g pulse
Vibration 5 to 27.5 cps	±1.3g
27.5 to 52 cps	0.036 in.
52 to 500 cps	±5g
Capacity — (Nominal) — bits	40,000
Data Storage Tracks	32
Adjustable Registers	4
Clock and Timing Tracks	4

LFE
COMPUTER PRODUCTS DIVISION

LABORATORY FOR ELECTRONICS, INC.

1079 COMMONWEALTH AVE. • BOSTON 15, MASSACHUSETTS

CIRCLE 42 ON READER-SERVICE CARD

CONTROL COSTLY ARGON, HELIUM & OTHER GASES

with NEW Harris multi-stage precision metering regulators

1 Four times as accurate (within 3%) as most flowmeter type metering regulators.

2 Easily read gauge dial designed to show actual flow in cubic feet per hour consumed.

3 May be attached to the cylinder in any position and accuracy of flow is not affected.

4 Constant flow, as originally set, is maintained as the content of the cylinder decreases.

5 No gaskets to loosen, causing loss of gas and erroneous reading of flows.

Delivery range from vacuum pressures to 2500 lbs.

Applicable to most gases.

Give us information on your particular requirements.

Model No.	Type	Delivery in cu. ft. per hr. (S.C.F.H.)	Inlet Connection CGA No.
92 AR	Argon	0-40	580
92 ARA	Argon	0-40	540
92 ARX	Argon	0-100	580
92 HE	Helium	0-125	590
92 O_2	Oxygen	0-100	540
92 CO_2	Carbon Dioxide	0-100	320
92 N_2	Nitrogen	0-100	580
92 H_2	Hydrogen	0-100	350

Note: If inlet connection other than standard required, specify CGA No.

Other regulators are available for other gases.

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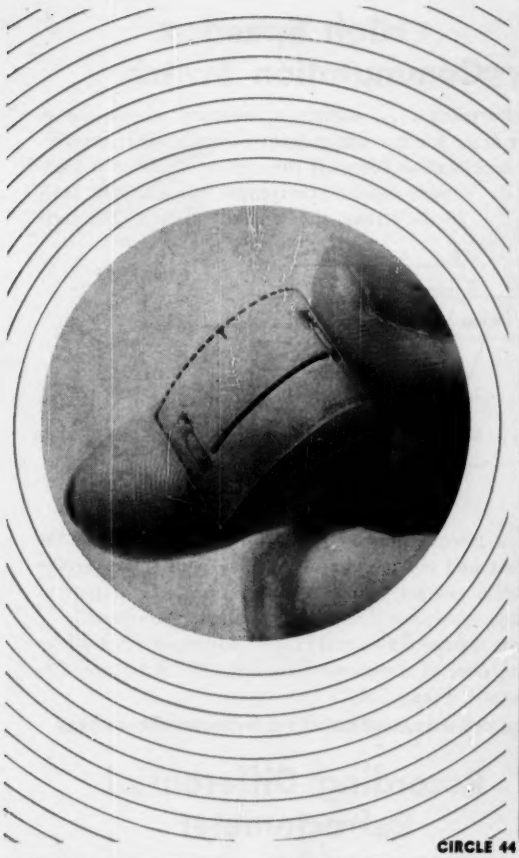

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For Application to: Structural Members • Transducer Sensors

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- Integral terminal construction
- Superior signal-to-noise ratio
- Resistance—350
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- Radius of Curvature—½"
- Maximum Operating Strain—over 3000 microstrain

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ADDITIONAL INFORMATION ON REQUEST

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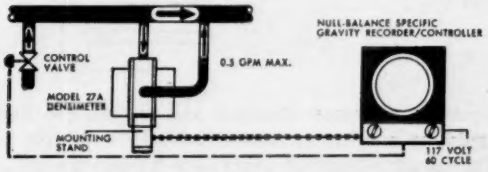
CIRCLE 44 ON READER-SERVICE CARD

ICS BRIEFS

Analog Densimeter

In the Pottermeter Densimeter, fluid is piped into the measuring chamber where the density sensor is

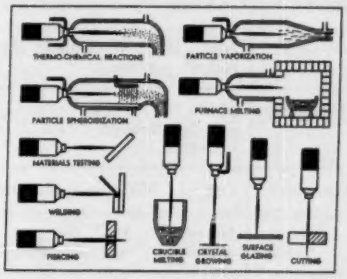


positioned by the buoyant force of the fluid. A precise angular position of the density sensor exists for each fluid density . . . and is transmitted through the Densimeter housing by means of a pulsed magnetic circuit . . . The fluid does not contact any of the electrical components in the measuring circuit. The density sensor actually consists of three solid density sensing units spaced approximately 90 - 100° and assembled to a common shaft . . . Since the density sensor is solid, pressure will have no effect on its volume . . . (*From* 4-*page Bulletin S-5, Potter Aeronautical Corp., U. S. Route* 22, *Union, N. J.*)

FOR THIS LITERATURE CIRCLE 176 ON READER-SERVICE CARD

Plasma Torches

Two new electrode designs in Plasma Flame Torches generate up to 50,000°F (five times that of the sun's surface) through thermal energy produced when a gas



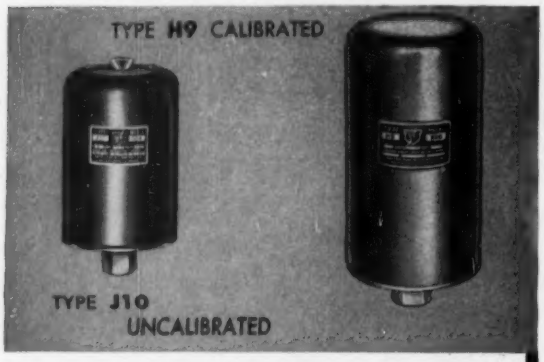
such as nitrogen is dissociated and ionized by an electric arc, resulting in a flame-like stream (plasma). Up to now, the maximum enthalpy, or heat content, of nitrogen plasma produced by arc-heated gas torches has been in the range of 16,000 Btu/lb. This new, low velocity, silent flame operates continuously at enthalpies up to 60,000 Btu/lb . . . with no appreciable surface disturbance . . .

A second electrode design permits continuous operation with nitrogen at enthalpies up to 20,000 Btu/lb, with a Mach 1 velocity of approximately 9000 ft/sec at an exhaust pressure of 1 atmosphere . . . (*From* 2-*page Bulletin* 140, *Thermal Dynamics Corp., Lebanon, N. H.*)

FOR THIS LITERATURE CIRCLE 177 ON READER-SERVICE CARD

Sensitive H9 J10

PRESSURE and VACUUM CONTROLS



UNITED ELECTRIC's Type H9 and Type J10 controls are highly sensitive precision built pressure and vacuum controls designed for applications where close on-off differentials and constant repeatability are required. Type J10, being uncalibrated, is smaller and less expensive than Type H9 which is calibrated and has a knob & dial adjustment.

Specs:	
Various Ranges	H9-J10 — between 30" Hg. Vac. and 15 P.S.I.
Switch Differentials	H9 — ½ to 1 ±1/10" W.C. depending upon model. J10 — ¾ to 1 ±3/10" W.C. depending upon model.
Switch Ratings	Standardly 3 amps 115/230 A.C.
Switch Types	N.O., N.C., or Double throw, no neutral position.
Electrical Connections	Made to screw terminals on switches through clearance hole in enclosure.
Pressure Connections	One ¼" NPT pressure connection.
Size	H9 — 7" x 3⅜" dia. J10 — 6⅛" x 3⅜" dia.
Approximate Weight	H9 — 3 lbs. J10 — 2¾ lbs.

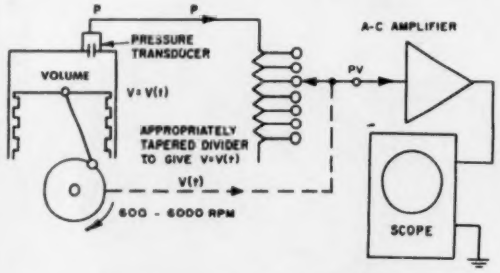
UNITED ELECTRIC *manufactures a complete line of temperature, pressure, and vacuum controls. For applications requiring custom-built units or modified standard units, call upon a UE application engineer for recommendations. Write for complete specification and pricing data on the Types H9 and J10. Similar data available on all other UE controls.*

United Electric Controls
COMPANY
85 SCHOOL STREET, WATERTOWN MASS.

CIRCLE 45 ON READER-SERVICE CARD

High Speed Commutation Switch

Deltaswitch . . . utilizes a mercury stream for a wiper arm. A rotor lifts mercury from a pool; centrifugal acceleration forces it through a nozzle as a high velocity stream against peripheral commutator contacts . . . As the stream momentarily strikes each con-

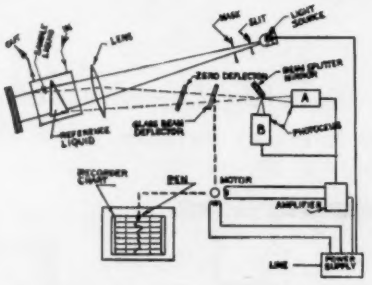


tact, a low-resistance path is established between the contact and the mercury pool. The pool serves as the common contact in the commutator . . . Diagram of analog multiplier illustrates simplicity of system . . . (*From 4-page Bulletin ATL-19, Advanced Technology Labs., Div. of American-Standard, 369 Whisman Rd., Mountain View, Calif.*)

FOR THIS LITERATURE CIRCLE 178 ON READER-SERVICE CARD

Recording Differential Refractometer

New Differential Refractometer measures index of refraction changes as small as 0.0000007 index of refraction units . . . A light beam is directed through a slit and lens to the sample cell . . . through the sample



liquid, a reference standard and the sample liquid again, to a mirror mounted behind the sample cell. The mirror reflects the beam back through the cell . . . The beam is then divided by a beam splitter mirror. Each half of the beam falls on a Cadmium Sulphide Photocell . . . Any change in the refractive index of the sample liquid causes the beam to shift . . . The photocell detector circuit becomes unbalanced and a signal is impressed on the amplifier. The amplified signal excites the recorder motor and it drives the beam deflector in a direction that equalizes the light falling on the two photocells . . . The position of the deflector, therefore, is a measure of the refractive index of the sample . . . (*From 2-page bulletin, Waters Associates, 45 Franklin St., Framingham, Mass.*)

FOR THIS LITERATURE CIRCLE 179 ON READER-SERVICE CARD

THANK YOU, COMPETITION!

Thank you control valve manufacturers. We see by your ads in the trade press and your exhibits at shows, that you are now offering split-body valves with cylinder actuators.

As most of you know, we have been manufacturing and marketing our Series LB split-body, cylinder-actuated valve for ten years. When we first started making the Series LB control valve—a radical departure from the then conventional double-seated valve with spring and diaphragm actuator—we did it because we sincerely believed it was the best way to control process fluids.

Those of us who pioneered the split-body, cylinder-actuated valve invested considerable time, money and effort in extolling its many features. As the years went by and user acceptance increased, we became stronger in our belief. However, there were many times during those years when we would have welcomed confirmation from you in the form of competitive products. Now, your announced entry into this field is, to us, a gratifying endorsement of the concept we have spent so much of our energies in developing. The added impetus that your collective advertising and sales efforts will give to publicize the benefits of the split-body, cylinder-actuated valve will contribute materially to its universal acceptance.

Although we know we have a good product backed by a decade of design and manufacturing experience, we do not intend to rest on our laurels. We will continue to offer industry the very best control valve we can make. And you will strive to outdo us. Your customers—and ours—and our industry—can only benefit from this healthy competition. Again, we thank you for following this lead in control valve technology.

CONOFLOW SUBSIDIARY WILKINSBURGH

CONOFLOW CORPORATION

FOREMOST IN FINAL CONTROL ELEMENTS

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CIRCLE 46 ON READER-SERVICE CARD

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with

Clean Dry Oil-Free Compressed Air

An Adams aftercooler and cyclone separator installed in your instrument air supply cools the discharge air to within 2° of cooling water temperature. Over 90% of the moisture and virtually all of the oil are condensed. The exclusive Adams cyclone separator then removes the condensed liquid oil and water and other foreign material with uniform high efficiency — over the entire operating range. This air is entirely suitable for air motor and most control applications. When bone dry air is needed, the chemical drier load is then limited only to polishing action, since the bulk of the moisture will have been removed by lower cost condensation. Why not review the cost cutting advantages of an Adams aftercooler-separator combination? Ask today for your free copy of Bulletin 714. R. P. Adams Co., Inc., 265 East Park Drive, Buffalo 17, New York.

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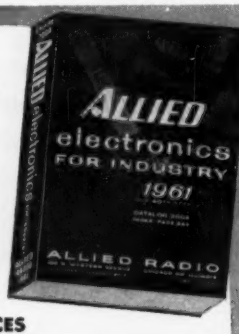

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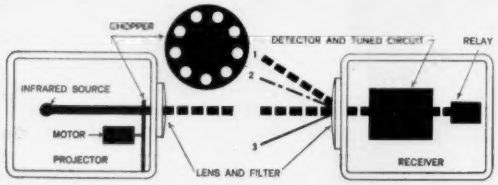
Infrared Photoelectric Control

Infrabeam Projector generates a powerful beam of infrared radiation, which is either directed at the Receiver across a space where it will be interrupted by an object . . . or reflected into the Receiver by the



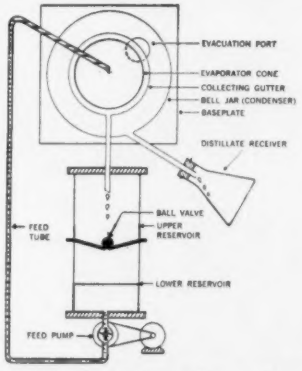
object itself . . . The Projector contains a motor-driven "chopper" disc which rotates at high speed in front of the source, causing the beam to flicker about 450 times per second. The Receiver . . . tuned exactly to this flicker frequency, . . . operates the internal heavy-duty relay which controls the "load" circuit—an alarm system, counter, motor, . . . or any other type of electrically actuated device . . . (*From 8-page bulletin, Cramer Controls Corp., Electronics Div., Centerbrook, Conn.*)

FOR THIS LITERATURE CIRCLE 180 ON READER-SERVICE CARD

Centrifugal Molecular Stills

The heart of the centrifugal molecular still is a concave, heated, evaporator-cone rotating within a chamber maintained at pressures as low as 1 micron Hg.

Distilland is metered by the feed pump into the center of the spinning evaporator-cone and is spread by centrifugal force rapidly and evenly outward in a

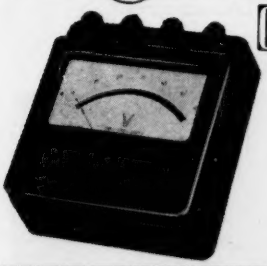


thin molecular film over the entire surface . . . As the film spreads and is heated, the vaporizable fraction, directly exposed to the high vacuum, evaporates and leaves the surface to condense on the cooler surface of the adjacent condenser wall . . . Evaporization takes place almost instantaneously . . . With the help of centrifugal force, the unvaporized residue slides into a gutter around the cone edge and is piped out of the still. The distillate product flows by gravity into distillate discharge pipes and is separately transferred out of the still . . . (*From 16-page Bulletin 3-1, Consolidated Vacuum Corp., 1775 Mt. Read Blvd., Rochester 3, N. Y.*)

FOR THIS LITERATURE CIRCLE 181 ON READER-SERVICE CARD

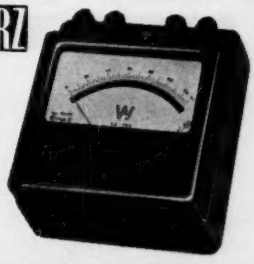
Physics Research Laboratories Inc.

"House of Fine Instruments"



MOVING COIL INSTRUMENTS FOR A.C. AND D.C.

• A wide range of millivoltmeters, voltmeters, microammeters, ammeters for D.C. • Voltmeters and milliammeters for A.C. • Accuracy for D.C. instruments 0.5%; for A.C. 1.5%. • Accessories to extend ranges. • Compact • Inexpensive.



PRECISION MOVING IRON INSTRUMENTS FOR A.C. AND D.C.

• Voltmeters milliammeters, ammeters. • Accuracy. for A.C., 0.5%; for D.C., 1.0%. • Both A.C. and D.C. • Frequencies up to 500 cps and 1000 cps.

PRECISION ELECTRODYNAMETER WATTMETERS

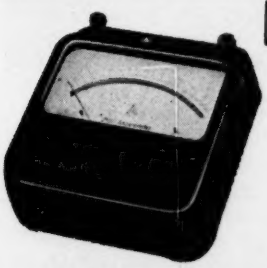
• Single phase and three-phase, 3 wire and 4 wire. • Frequency to 1000 cps • Accuracy 0.5%.

UNIVERSAL MULTI-RANGE INSTRUMENTS

• Famous Goerz AC/DC voltage–current instruments. • Accuracies as high as 1.0% on D.C. • Cut-out overload protection. • Accessories to extend ranges. • Dust-proof, moisture-proof. • Resistance • Capacitance • Temperature Measurements • Up to 48 ranges.

PRECISION AMMETERS AND VOLTMETERS FOR A.C. AND D.C.

• Wide selection of ammeters and voltmeters. • Both A.C. and D.C. • Accuracies of 0.2% on A.C.; 0.5% D.C. • Range selection switch. • Calibration certificate with each instrument. • Up to 1500 volts with accessories.



MOVING COIL D.C. STANDARDS

• Wide selection of voltmeters, millivoltmeters, microammeters, milliammeters. • Accuracy of 0.2%. • Special 12-range millivolt-voltmeter and 11-range milliammeter-ammeters, also 0.2% • Accessories to extend ranges. • Calibration certificate with each instrument.

ELECTRODYNAMIC PRECISION STANDARDS

• Voltmeters, ammeters, milliammeters, wattmeters, power-factor meters. • Accuracy 0.2% on all but power-factor meters. • Frequencies to 1000 cps, 1600 cps and 2500 cps. • Calibration certificate with each instrument.

LABORATORY PRECISION D.C. STANDARD

• Millivoltmeter, millivolt-voltmeter, voltmeter. • Up to 1500 volts with accessories, up to 300 amperes with accessories. • Accuracy of 0.1%. • Transverse scale with mirror. • Calibration certificate.

HIGH SENSITIVITY GALVANOMETERS, MILLIVOLTMETERS AND MICROAMMETERS

• Famous Goerz double-light spot galvanometers. • 21-range light spot DC universal instrument.

PRECISION MULTI-RANGE A.C. AMMETER

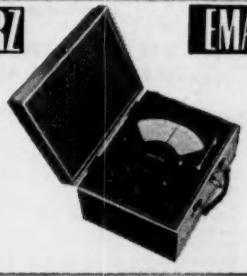
• 8 ranges: 0.2-0.5-1-2-5-10-20-50 amperes. • Accuracy of 0.2%. • Range selector switch. • Shielded against stray fields. • Calibration certificate.

MEGOHMMETERS

• Up to 10,000 megohms. • Accuracy 1.0% • Completely self-contained. • Instructions on front plate. • Models for operation on 220 VAC line voltage. Combination megohmmeters and earthtesters.

MINIATURE WHEATSTONE BRIDGE

• 1.0 to 150,000 ohms. • Accuracy of 1.0%. • Folds into package 5" x 4" x 3", has own carry strap. • 2.5×10^{-6} ampere galvanometer. • Range up to 1.0 megohm with external resistor.



POWER CIRCUIT ANALYZER

• 9 current ranges from 150 ma to 60 amp.; may be extended up to 13 with plier-type transformer. • 4 voltage ranges, up to 600 volts. • Active power; 9 watts to 900 KW (with transformer.) • Reactive power; 9 VAR to 900 KVAR (with transformer.) • Power factor; 0-1, capacitive and inductive. • Frequency; 57-63 cps. • Light weight.

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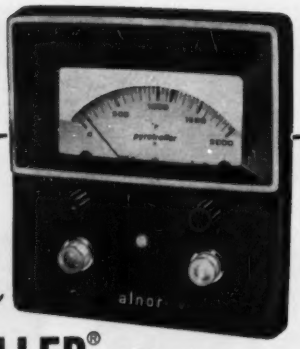
CIRCLE 48 ON READER-SERVICE CARD



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Alnor
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An electronic temperature controlling instrument that automatically controls the heat source to maintain a constant temperature within a set range.

Designed for temperature control on heat treating furnaces, ovens, heat sealing equipment, plastic moulding machines, cooking vessels, or any application where a precise uniform temperature must be maintained.

Various temperature ranges, –100° F. up to 3000° F. can be supplied to meet your requirements. Our engineering service is available for special applications.

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CIRCLE 49 ON READER-SERVICE CARD

A. D. JONES OPTICAL WORKS

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ALUMINUM
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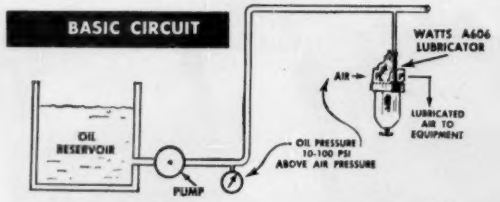
BARIUM TITANATE
BISMUTH
BRASS
CARBORUNDUM
CERAMIC
COBALT FERRITE
COPPER
*CORNING 707
*CORNING 7052
COPROUS BROMIDE
FERRITE
FERROX
**FLUORIDE, CALCIUM
**FLUORIDE, LITHIUM
GALLIUM ANTIMONIDE
GALLIUM ARSENIDE
GARNET
GERMANIUM
GOLD
INDIUM ANTIMONITE
INDIUM PHOSPHIDE
INDOX
IRON SINGLE CRYSTAL
LITHIUM
MAGNETIC PLUMBITE
MELAMINE FIBER GLASS
MICA, SYNTHETIC
NICKEL OXIDE
PLATINUM
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
**SAPPHIRE
**SODIUM CHLORIDE
**STEEL
STRONTIUM TITANATE
TEFLON
TITANIUM DIOXIDE
*VYCOR
*X-RAY LEAD GLASS
ALL TYPES KNOWN GLASS

* Carried in stock
** Purchased for orders

CIRCLE 50 ON READER-SERVICE CARD

Automatic Lubrication

A completely automatic lubrication system consists of a means to supply oil continuously to one or more lubricators within the system. A medium-pressure oil

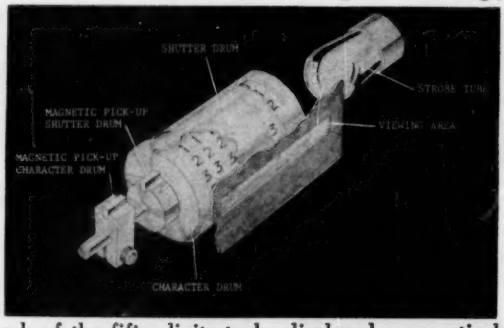


supply line runs from a pump-reservoir to the most remote lubricator; individual feed lines from this supply maintain automatic oil level for all lubricators in the system. As long as the required minimum oil supply line pressure is maintained, automatic fill lubrication will continue . . . (*From 22-page Catalog 616F, Industrial Div., Watts Regulator Co., Lawrence, Mass.*)

FOR THIS LITERATURE CIRCLE 182 ON READER-SERVICE CARD

Stroboscopic Digital Display

Kearfott's Digistrobe digital display employs the stroboscopic principle to provide an in-line, in-plane, high-definition, white-on-black display . . . In operation, a character drum inscribed with an array of symbols rotates continuously at 6000 rpm . . . The array consists of 5 columns of ten digits (0-9) each. The character drum is directly geared to and rotates within an outer shutter drum which rotates at 1200 rpm, one-fifth the speed of the inner drum. On the face of the shutter drum are five windows, each of which occupies one-fifth of the circumference and corresponds to a single column of digits. Accordingly,

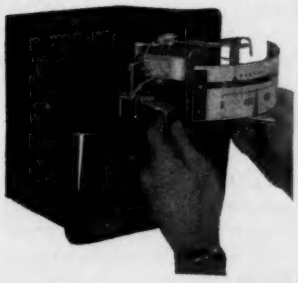


each of the fifty digits to be displayed consecutively appears in the viewing areas as follows: during the first revolution of the inner character drum, the digits 0-9 of the first column appear, the remaining columns being masked by the shutter drum; during the second revolution of the inner character drum, the digits 0-9 of the second column appear, the remaining columns being masked by the shutter drum, etc . . . When the desired digit appears in the viewing area, the switching matrix transmits a trigger pulse to a special high-speed, internally-mounted Xenon stroboscopic light . . . that emits a short intense flash which illuminates the digit. . . . A five-digit display appears as a fixed display . . . (*From 4- page Bulletin, Kearfott Div., General Precision, Inc., Little Falls, N. J.*)

FOR THIS LITERATURE CIRCLE 183 ON READER-SERVICE CARD

Ever try threading a needle
WITH ONE EYE CLOSED?

The interchangeable unit design of Wheelco Capacitrols provides the ultimate in control-instrument flexibility . . . permits on the job modifications to meet changing production demands.



TRYING to meet today's process control requirements with yesterday's instrumentation is like trying to thread a needle with one eye closed! Today's rigid processing demands the accuracy and flexibility of Wheelco Capacitrols. Why? Wheelco's interchangeable unit design (see left) for maximum flexibility permits on-the-job instrument modifications to meet changing production demands . . . plug-in chassis for fast servicing . . . a wide variation of control forms such as time-proportioning Capacitrols when system inertia compensation is necessary . . . or electric-proportioning Capacitrols for saturable core reactor control (a Wheelco first). Without qualification, Wheelco Capacitrols offer the most accurate and flexible process forms available. Ask your nearby Wheelco sales and service representative to give you complete data on all Wheelco instruments. After all, if you're using obsolete process control instrumentation, we both lose . . . right?

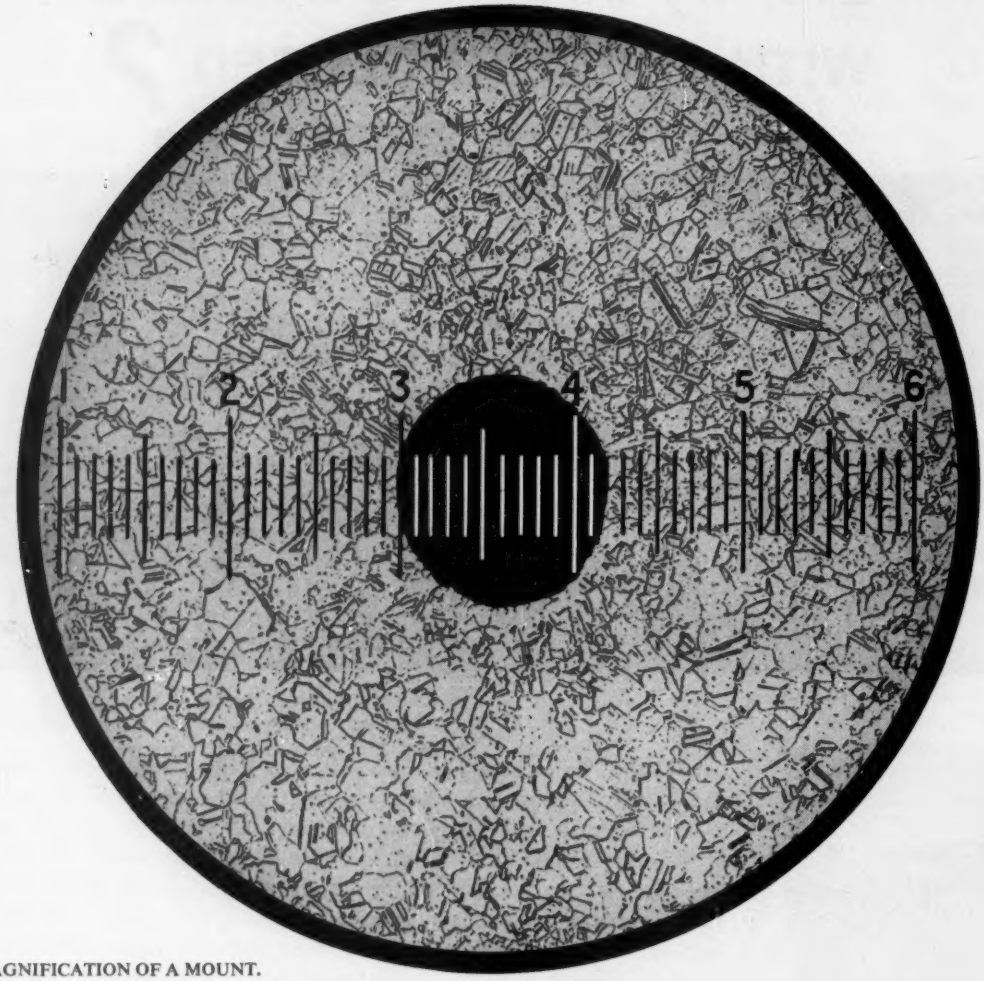
WRITE FOR COMPLETE ENGINEERING DATA

In addition, Wheelco Capacitrols offer exclusive "Electronic Link" no-contact control, flexibility of sensing elements, thermocouple break protection and many other advantages.

BARBER COLMAN

BARBER-COLMAN COMPANY
Wheelco Industrial Instruments Division
Dept. A, 1515 Rock Street, Rockford, Illinois, U.S.A.
BARBER-COLMAN of CANADA, Ltd., Dept. A, Toronto & Montreal
Export Agent: Ad. Auriema, Inc., N.Y.

CIRCLE 51 ON READER-SERVICE CARD



100X MAGNIFICATION OF A MOUNT.
Each division .001 in.

Capillary ID size is checked under 100x magnification

—yet this critical inspection is only 1 of 3 used to check ID of Superior capillary tubing

At Superior, in checking the ID size of capillary tubing we don't rely on only one reading from our inspection microscope, we require four. Then we double-check in two other ways—one the use of a relatively simple plug gage, the other a comprehensive flow inspection to ascertain the average ID dimension. These inspections also give you assurance of a free passage through the bore, uniformity of ID surface and a satisfactory grain structure.

Superior has spent years in the development of manufacturing processes and quality control procedures for the production of close tolerance capillary tubing. ODs range up to 3/16 in., IDs from .004 through .040 in. Analyses include Types 304, 316, 321, 347 and 446 stainless; also Monel, Inconel, nickel and carbon steel alloys. Data Memorandum No. 11 gives complete details—let us send you a copy. Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing
NORRISTOWN, PA.

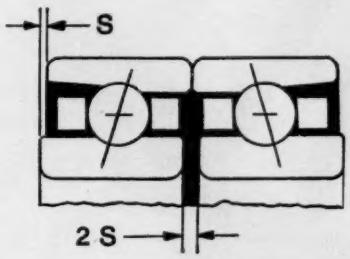
All analyses .010 in. to 5/8 in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

CIRCLE 52 ON READER-SERVICE CARD

Duplex Bearing

When emphasis is placed on the rigidity with which instrument parts must be supported, that is, the accuracy and resistance to deflecting forces, bearings in preloaded duplex pairs are often used. In such



pairs, bores and outside diameters are very closely matched and critical face stickout (offset S) held to within minute tolerances. The resultant internal fit-up when mounted with the bearing faces abutting so that stickout for both bearings (2S) is eliminated is such as to assure maximum rigidity with the least possible effect on bearing torque.—(*From* 36-*page catalog, New Departure Div., General Motors, Bristol, Conn.*)

FOR THIS LITERATURE CIRCLE 184 ON READER-SERVICE CARD

Multi-Conductor Magnet Wire

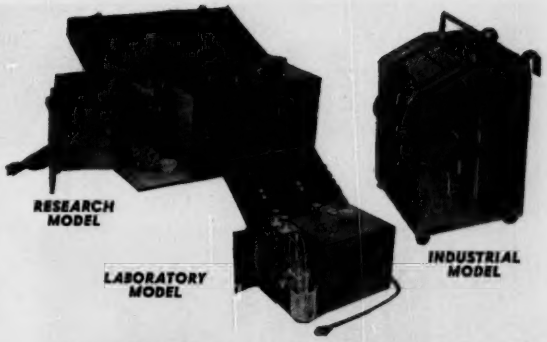
Formvar insulated wire is available in multiconductor cables of the ribbon type. The round wires are bonded into flat cables, using any number of conductors from 2 to 30, and gauges from 26 to 44 . . . *Spectra-Twist* flat cable consists of twisted pairs; *Verilocap* is spaced cable for very low inter-conductor capacitance; *Magna-Strip* is flat cable of magnet wire. . . . *Spectra-Temp*, flat cable of thermocouples, gets rid of the "rats nest effect" in multi-channel temperature recording . . . (*From* 4-*page bulletin, Spectra-Strip Wire & Cable Corp., Box* 415, *Garden Grove, Calif.*)

FOR THIS LITERATURE CIRCLE 185 ON READER-SERVICE CARD

Forward-Backward Counter

The Forward-Backward is essentially the same basic counter circuit described. Additional Pulse Gates are connected to the basic counter to pass pulses when a Flip-Flop unit is in the zero state. Pulses applied to the backward input will cause the Flip-Flops to change in the series 1111, 1110, 1101, 1100 . . . whereas pulses applied to the forward input will cause the Flip-Flops to follow the series 0000, 0001. 0010, 0011 . . . As shown, this digital circuit is readily effected through the interconnection of DATA BLOC (or DATA-PAC) Model 1011 Flip-Flops, Model 1101 Pulse Gates and a Model 1431 Variable Frequency Clock . . . (*From* 8-*page brochure, Harvey-Wells Electronics, Inc., Covering Shift Registers, etc.,* 14 *Huron Dr., Natick, Mass.*)

FOR THIS LITERATURE CIRCLE 186 ON READER-SERVICE CARD



Cambridge pH Meters

The three portable models illustrated above incorporate new and important advantages. A.C. line operation eliminates battery nuisance. Laboratory and Research models use electron-ray tube for precise null-point indication. Industrial model is direct-reading, continuous-indicating; ruggedly built for plant use.

Accuracy: Research .02 pH, Laboratory .05 pH, Industrial .10 pH. Cambridge pH equipment also includes single- and multi-point indicators and recorders. Send for Bulletin 910-M.

CAMBRIDGE INSTRUMENT COMPANY, INC.
1661 Graybar Bldg., 420 Lexington Ave., New York 17, N. Y.

Pioneer Manufacturers of
PRECISION INSTRUMENTS

CIRCLE 53 ON READER-SERVICE CARD

INSTANTLY MEASURES COMPRESSION OR TENSILE LOADS

- Accurate to within 1% of full scale capacity.
- Jewelled dial indicator repeats perfectly.
- Shockless mechanism for rough jobs.
- Red maximum pointer registers peak loads.
- Optional switch controls mechanisms.
- Accommodates wide variety of attachments.
- Available as combination push-pull model.
- Extremely compact. Fits into "tight" spaces.
- Flexes millions of cycles without damage.

12 different capacities from as low as 0-10 lbs. up to as high as 0-50,000 lbs.

WRITE FOR FREE ILLUSTRATED CATALOG AND PRICE LIST

P-56

W.C. Dillon & CO., INC. 14584 Keswick St. Van Nuys 13, Calif.

CIRCLE 54 ON READER-SERVICE CARD

Cubic precision digital voltmeter withstands 50G shock

A new militarized version of the Cubic precision digital voltmeter is guaranteed to withstand shocks as high as a bone-crushing 50 G. The ability to shake off punishment that would wreck ordinary voltmeters, and to keep on performing perfectly for years and years under the hardest kind of use, is built into *every* Cubic digital voltmeter. These meters are "operator-proof" – they will not be damaged by any except the most flagrant misuse. Even voltages 100% over the top of the highest range will not harm them.

The advanced engineering of Cubic's transistor-driven stepping-switch design provides extraordinary reliability and accuracy. Cubic digital voltmeters achieve 99.997% repeatability, for precise accuracy again and again. Attenuator accuracy is 0.003% for wide-range precision. Bridge linearity of 0.003% is attained with carefully matched quality components. Noise rejection (60 cps) is 80 db.

Cubic's digital readout is simple, reliable and the easiest to read at a glance. Extra quality components throughout ensure minimum maintenance requirements. Before buying *any* digital instrument, investigate the best. *Write for descriptive literature to Dept. IC-100, Industrial Division, Cubic Corporation, San Diego 11 Calif.*

BRIEF SPECIFICATIONS – MODEL 2100

ENVIRONMENTAL

shock test: will withstand 50G Navy shock test, and shipboard vibration

humidity: 100%

salt spray and fungus resistant

ELECTRICAL

volts: 0.01% accuracy from 1 millivolt to 1000 volts, automatic ranging and polarity

ohms: 0.1 ohm to 10 megohms, manual ranging

input power: 25 watts

ratiometer provision and switching

MECHANICAL

size: 5½" wide, 11¼" high, 14" deep

weight: 35 lb

cubic
CORPORATION

CIRCLE 55 ON READER-SERVICE CARD

THE ENGINEERING SHORTAGE

D. J. KIPP, P. E.
Los Angeles, Calif.

THERE IS NO SHORTAGE of engineers, but there is a shortage of engineering-quality engineers. The single greatest cause for this shortage is the lack of adequate compensation and respect afforded to the engineering profession, in that order of importance. Many well qualified engineers leave the engineering field for positions in other fields offering more money and status.

If the engineer wants a higher level of respect and income he must earn it, and refuse to accept less.

The professional engineer needs a strong association similar to the Bar Association and the American Medical Association to set up standards backed by law, and to discipline the engineering profession. The foundation of such an association exists in the Founder's Society; the first step of legislation has been taken in the Professional Engineering State licensing.

Law

The next important step should be the restricting by law of the use of the title "Engineer," such title to apply only to *licensed Professional Engineers.* Also, to require by law the signature of licensed Professional Engineers on a greater amount of engineering work, such as in the fields of Refrigeration, Air Conditioning, Machine Design, etc.

Any person not licensed as a Professional Engineer should not be allowed legally to refer to himself as an "Engineer." This should include Doctors of Science and Engineering graduates that have not received their professional license. Those men who are doing technical work and who have been calling themselves engineers should be referred to as technicians. A Doctor of Science should not automatically qualify a man as a Senior Engineer any more than a Licensed Engineer is automatically qualified to be a Doctor of Science.

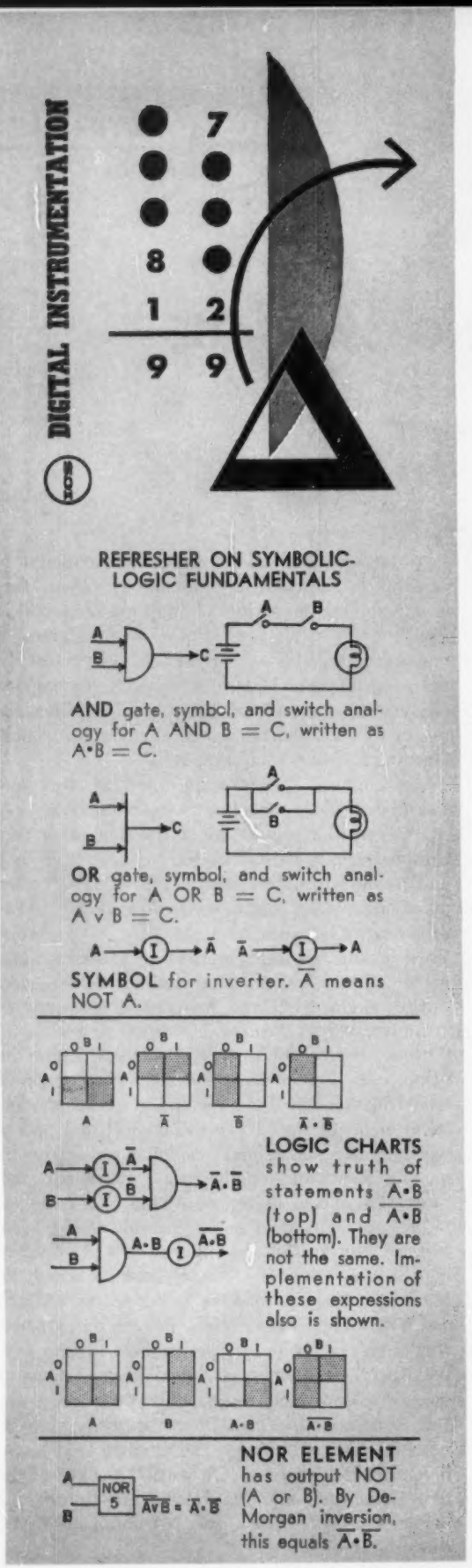
An expansion of the advertising campaign to educate the public on the protection to themselves of having the signature of licensed Professional Engineers on sales agreements involving engineered equipment and services would not only protect the public from purchasing improperly engineered equipment or installations, but would further the raising of the standards of the engineer, thus making the profession more desirable.

The engineer goes through years of work and sacrifice to obtain a college education. If he does not receive the respect and income of other professional groups he will use his above-average I.Q. and training to earn status in other fields. Today, many engineers would do everything they could to discourage their sons from going into engineering. Their feelings are based on the time wasted qualifying as an engineer versus the gains to be expected.

Most engineers choose engineering because they are interested in creative, constructive work—and they are hungry for further education in new developments. For instance, the mechanical engineer would like electrical and electronic work, the electrical engineer would like mechanical and optical work. Management should exploit these desires by making accredited engineering courses and lectures available to its technical staff.

The productivity of an engineering staff can be increased by treating the engineer as a professional man, not as an hourly laborer, and by supplying him with adequate staff including secretaries and assistants. The engineer will deliver the greatest results only when he has proper help to take over detail work. The engineer should have his *team* of designers, draftsmen, clerks, and secretaries.

In conclusion, the quality and quantity of engineering work will rise as the engineer (1) earns his professional license, (2) restricts the use of the term "engineer" only to Professional Engineers, (3) demands adequate staff, and (4) continually educates himself.


DIGITAL INSTRUMENTATION
7
8
1 2
9 9
REFRESHER ON SYMBOLIC-LOGIC FUNDAMENTALS
A
B
C
AND gate, symbol, and switch analogy for A AND B = C, written as A•B = C.
OR gate, symbol, and switch analogy for A OR B = C, written as A v B = C.
SYMBOL for inverter. Ā means NOT A.
LOGIC CHARTS show truth of statements Ā•B̄ (top) and A•B (bottom). They are not the same. Implementation of these expressions also is shown.
NOR
5
NOR ELEMENT has output NOT (A or B). By DeMorgan inversion, this equals Ā•B̄.

DIGITAL COMPARISON BY NOR LOGIC

JOHN M. BOSWELL, Radiation, Inc.

Only two NOR elements are required to make an inequality comparison of two bits; only four for an equality comparison.

IN DATA PROCESSING, computation and process control, it is frequently necessary to initiate different actions with the equality or inequality of two given parameters or digital words determining which action is to be taken. A simple example or application could be in a process control function, where the rate of flow must be kept equal. The rate of flow first would be digitized and then fed to a digital comparator, which could be made to trigger functions which might be as follows:

1. If flow A is equal to flow B, maintain settings and light appropriate indicator on control panel.
2. If flow A exceeds flow B, advance control valve on flow line B.
3. If flow B exceeds flow A, sound alarm and initiate predetermined safety measures.

Inequality Comparison

In implementing this function, let us first consider Table 1 in Fig. 1 for the function "A is greater than B." Since in a binary function the only parameters are "zero" and "one," the foregoing statement is the same as saying "when A is greater than B, A=1 and B=0," or, "A is greater

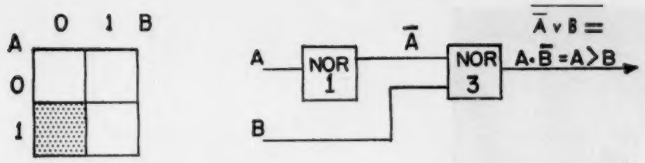


FIG. 1. STATEMENT A > B is the same as $A \cdot \bar{B}$, which is the output of NOR 3.

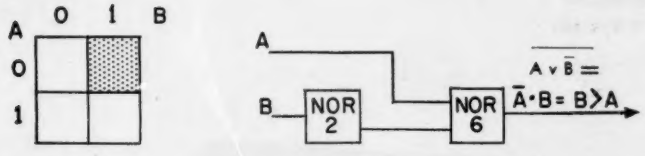


FIG. 2. OUTPUT of NOR 6 is $\bar{A} \cdot B$.

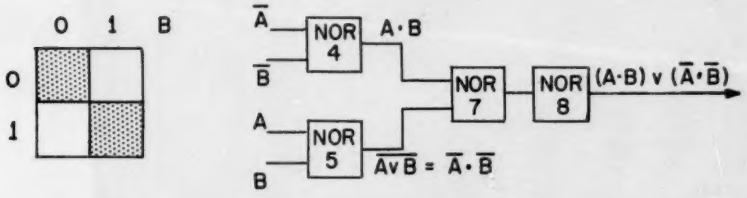


FIG. 3. OUTPUT of NOR 8 is $(A \cdot B) \vee (\bar{A} \cdot \bar{B})$, the two conditions for an equality comparison.

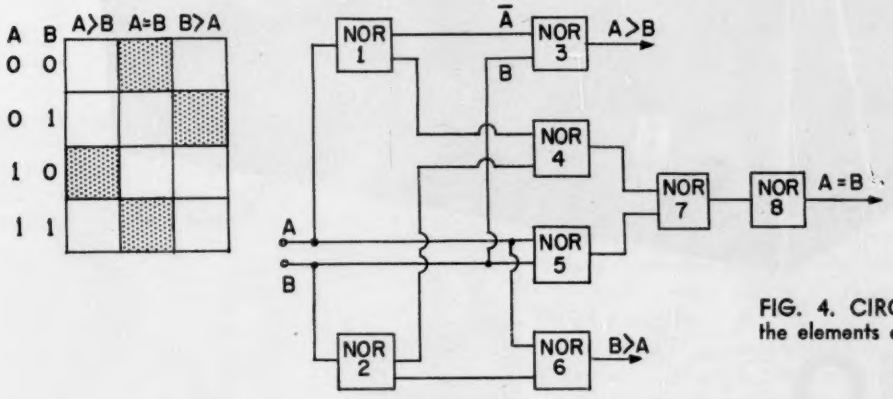


FIG. 4. CIRCUIT containing all the elements of Figs. 1, 2, and 3.

than $B = A \cdot \bar{B}$." This function is satisfied by the circuitry shown in Fig. 1.

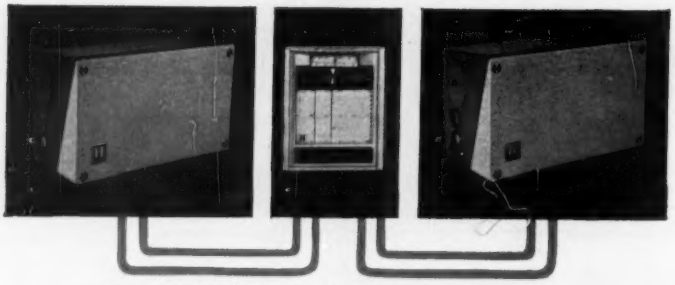
Fig. 2 shows solution for "B greater than A."

Equality Comparison

The determination of the two conditions of equality of A and B is shown in Fig. 3. This circuit should produce an output when either $A = B = 0$, or $A = B = 1$. Consider NOR 4. The two inputs $\bar{A}$ and $\bar{B}$ produce an output $\overline{\bar{A} \vee \bar{B}} = A \cdot B$, by the DeMorgan inversion. The output of NOR 5 gives $\overline{A \vee B} = \bar{A} \cdot \bar{B}$. The two resultants are fed to NOR 7 and 8, giving an output $(A \cdot B) \vee (\bar{A} \cdot \bar{B})$, which satisfies the desired conditions.

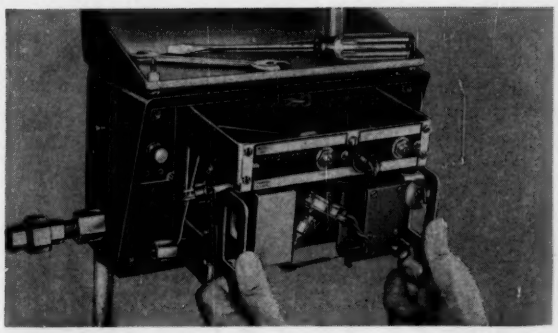
A circuit which includes all the elements of Figs. 1, 2, and 3 is shown in Fig. 4. This circuit makes both equality and inequality comparisons. For serial operation it is only necessary to add a delayed freedback loop as described previously in this series. *

*"Serial Comparison by Symbolic Logic," R. Brooks, *I&CS, May* 1960



***ElectriK Tel-O-Set*—the true 2-wire system**

NO STAND-BY SUPERVISION



No stand-by supervision needed when you install an *ElectriK Tel-O-Set* Control System. Installation crews never have to open an instrument cover to hook up the line . . . instrument crews never have to touch an outside line to service an instrument.

It's all in the *Tel-O-Set* connection system. All process connections are entirely isolated from the inside of the instrument case. Installation crews can mount, pipe, and wire the various *Tel-O-Set* instruments without removing the cover. Instrument chassis can be removed for servicing without breaking any external process or electrical connection. Standardized parts, together with extensive use of quick-connect and plug-in design, minimize downtime and reduce spare parts inventory.

And there's more to the *ElectriK Tel-O-Set* economy story. Specifically, there's no external power required at any field-mounted *Tel-O-Set* instrument. Line power connection is made only at the receiver. Two-wire d-c transmission reduces installation costs and eliminates shielding problems. Also, the 4-20 milliamp signal range of the system gives a live zero and permits the use of the most reliable transistors available. The d-c signal can be fed into data handling systems and millivolt-actuated instruments . . . can be easily transduced to a standard 3-15 psi pneumatic signal to operate existing pneumatic systems.

Take a new look at your control problem with the *ElectriK Tel-O-Set* System in mind! Get the complete economy story from your local Honeywell field engineer. Call him today . . . he's as near as your phone. MINNEAPOLIS-HONEYWELL, 21 Penn Street, Fall River, Massachusetts.

Honeywell

H HONEYWELL First in Control SINCE 1885

CIRCLE 56 ON READER-SERVICE CARD

Process Control Systems

FRED D. MARTON, Instruments Publishing Company

PUMP MOTOR IN REMOTE PUMPING STATION IS PROTECTED AGAINST DANGEROUS CONDITIONS IN SUCTION PRESSURE, DISCHARGE PRESSURE, AND MOTOR CURRENT

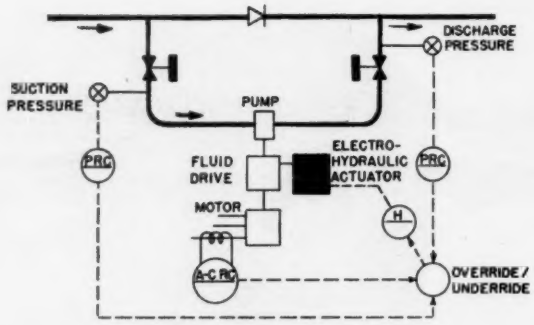
In a remote pumping station, which may be unattended, the pump motor should be protected against too low suction pressure (which can cause cavitation), too high discharge pressure (which can burst pipes), and excessive current (which can burn out the motor).

This system is for a constant-speed induction motor driving a centrifugal pump. Any of the dangerous conditions described will close the valve in the discharge line of the pump. The system is completely electric or electrohydraulic.

The three variables are fed to a unit called an override/underride adapter. The suction and discharge pressures are detected by pressure recorder-controllers (PRC). The motor current is detected by an a-c recording controller A-C RC. The override-underride unit is simply a parallel-diode circuit which permits either the highest or lowest of a given number of input signals to develop an output signal. Thus, if the discharge pressure or motor current becomes excessive, a signal is sent to the valve. Similiarly, if the suction pressure is too low, a signal is sent to the valve.

The valve programmer is a programming unit that permits the station to be replaced on the line after it is shut, by opening the main control valve at a safe rate while the pump motor is restarted.

The PRC's, A-C RC, Programmer, Over-Underride Unit, and Man-Auto Station can all be mounted at the



control station, with electric lines to the remote pumping station.

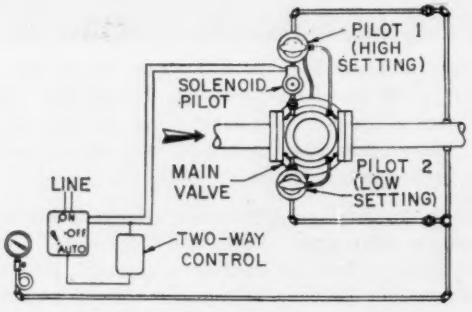
Equipment used: (2) pressure transmitters, Type P2T; (2) recorders, Type A5R with controllers, Type A8C, with proportional and integral (reset) control modes; manual loading station Model M4C/2; a-c recording controller, Model A5R-A8C with 5-amp current transformer of any reputable make; program controller, Model P3A/5; underride/override adapter, Type A5A; motor current adapter, Type A3A; converter, Model D2C/2 a-c/d-c; and control valve (type depending on piped fluid) with thermo-drive actuator.

Source: Swartwout Div., Crane Co., Manchester, N. H.

ELECTRIC SWITCH-OVER CONTROL FOR HIGH OR LOW SETPOINT

When pressure regulation in a process line requires a frequent switch-over from a high setting to a low setting, one pressure regulator can be used instead of two. By connecting two pilots to the main regulator, the set point of the main regulator (a spring-loaded, diaphragm-actuated type) quickly can be alternated to the desired value. The switch-over is performed remotely by electric means: A solenoid pilot valve between the pilot valve with the high setting and the main regulator, is actuated by a switch which permits on-off and automatic control of the solenoid valve. When the solenoid valve is opened the pilot with the higher setting overrides the other, keeping the main regulator open even when the pilot with the lower setting closes.

Equipment used: Type ED-M33D Pressure Regulator, consisting of (1) Type E main valve, (2) two Type D pressure pilots, (3) Type M33 solenoid pilot, (4)



accessories, like switch with on-off and automatic setting, and pressure gage.

Source: Spence Engineering Co., Inc., Walden, N. Y.

CIRCLE 57 ON READER-SERVICE CARD

Compact 4-way

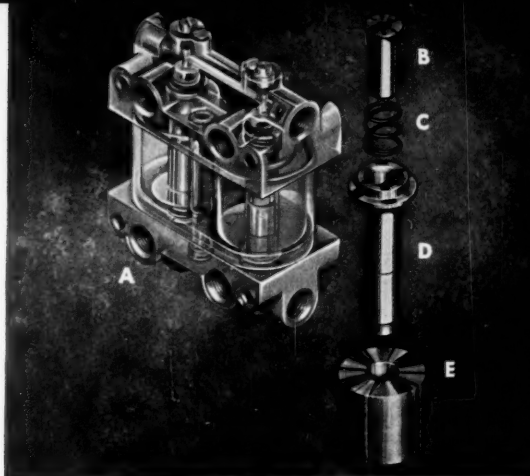
SKINNER

Solenoid Valves

assure precise cylinder control

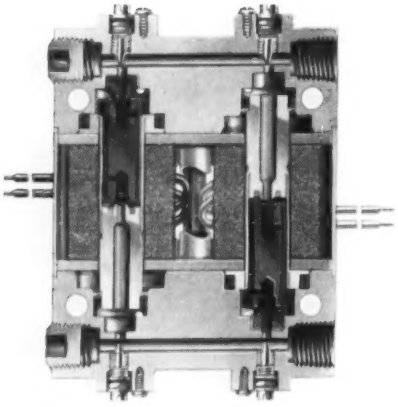
Here's how accurate, dependable operation is built into SKINNER 4-way solenoid valves

- **Precise flow control**—by adjustable metering
- **Compact, direct acting**—two 3-way valves in one housing
- **Durable and corrosion resistant**—stainless steel internal parts
- **Leakproof, bubbletight sealing**—soft, synthetic inserts
- **Positive operation mounted in any position**—spring-loaded plungers
- **Underwriters approved**—wide selection of coils, voltages and frequencies
- **Wired from front or rear**—housing easily reversed
- **Adaptable to many uses**—optional porting arrangements



A. Transparent view of 4-way solenoid valve B. Plunger
C. Plunger return spring D. Sleeve E. Coil

SKINNER four-way solenoid valves available in three basic types



The Skinner V9 solenoid valve is two 3-way valves in one compact housing. Both valves may be independently controlled and metered to provide accurate, dependable control of single- or double-acting cylinders, or larger pilot-operated valves.

V9 types are available without adjustable flow and with metering at both exhaust ports, both inlet ports or full metering of all ports.

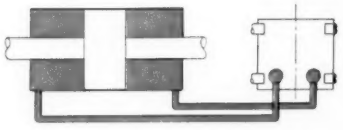
• • •

For complete information, contact a Skinner Distributor listed in the Yellow Pages or write us at the address below.

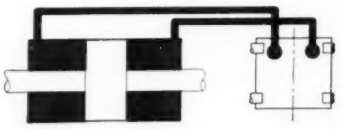
V9 SERIES SPECIFICATIONS

Media—air, hydraulic oils, inert gases
Orifice Diameter—$\frac{3}{64}$", $\frac{1}{16}$", $\frac{3}{32}$", $\frac{1}{8}$"
Pipe Size—$\frac{1}{4}$" NPTF
Maximum Operating Pressure Differential—0 to 150 PSI (up to 225 PSI also available)
Temperature Range—minus 40°F. to plus 180°F.
C_V Factor—$\frac{3}{64}$" .052, $\frac{1}{16}$" .095, $\frac{3}{32}$" .156, $\frac{1}{8}$" .214
Mounting—$\frac{1}{4}$" through-bolt holes.

Normally closed—normally closed V933 valves with a neutral position. Generally applied on double-acting cylinders where the piston is in a neutral position without pressure when both coils are de-energized. This permits manual shifting of the piston without operating the valve.



Normally open—normally open V955 valves with a neutral position. Generally applied on double-acting cylinders where both sides of the piston are to be open to pressure when both coils are de-energized. Under certain conditions, the first operating stroke of double-acting cylinders will be smoother with this valve in use.



Normally closed—normally open V935 valves with no neutral position. Generally applied on double-acting cylinders where the piston is to be in retracted or extended position with pressure when both coils are de-energized. Wiring is simple—both coils are operated simultaneously and can be controlled by one single-pole, single-throw switch.

When you specify solenoid valves, specify Skinner. Skinner solenoid valves are distributed nationally.

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THE STRANDUCER POTENTIOMETER

FIG. 1. JAMES S. LOCKE, (Vice President, left) and **J. A. ROBINSON** (Div. Sales Manager) of Brown Instruments inspect a STRANDUCER, now available in the new Honeywell strip-chart, circular-chart and circular-scale recorders and indicators.

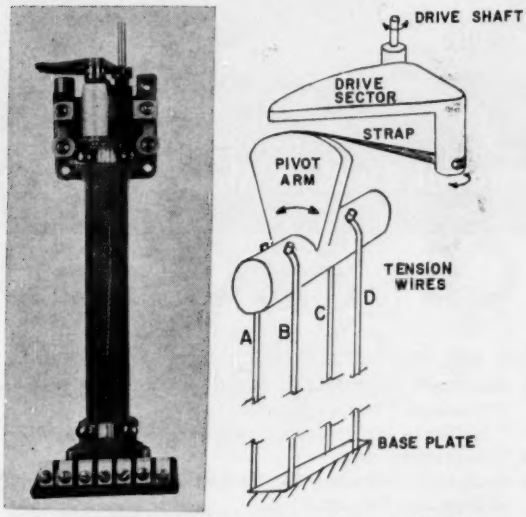


FIG. 2. STRANDUCER element (left) and principle.

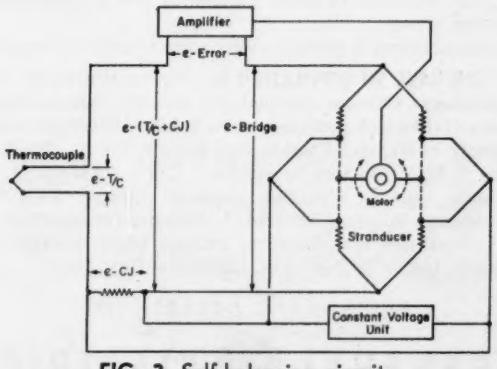


FIG. 3. Self-balancing circuit.

THE CONTINUOUSLY VARIABLE slidewire has been the heart of potentiometric measurement since 1852, when DuBois-Reymond introduced it into the emf-balancing (*kompensations apparate*) circuit described by Poggendorf in 1841. Today, the potentiometer (both manual and self-balancing) is perhaps the most common instrument for measurement of low (millivolt and microvolt) emf's.

The ever-increasing use of such measurements has emphasized the single basic limitation associated with the variable slideware—the moving contact. Many attempts have been made to eliminate it, but none has been accepted universally.

It is possible that a superior substitute has at last been developed—the *STRANDUCER* element, introduced at a press conference on January 5, New York, by the Brown Instruments Division of Minneapolis-Honeywell, a pioneer and giant in the self-balancing potentiometer field.

The new "ElectroniK 17" potentiometer replaces the moving contact on the voltage divider with a STRANDUCER (Figs. 1 and 2). This new "variable resistance" works on the strain-gage principle that a wire, when stretched, will change its resistance in proportion to its elongation.

Fig. 2 shows the STRANDUCER operation. Four wire strands are used. In the "dead zero" position, the four wires, in equal tension and of equal resistance, form four legs of a bridge circuit. The pivot arm, as it moves, increases the tension of two of the wires and decreases the tension of the other two. (The pivot arm is pulled by a strap wrapped around the hub of the drive sector. The drive sector is connected to the drive shaft, also with a strap.)

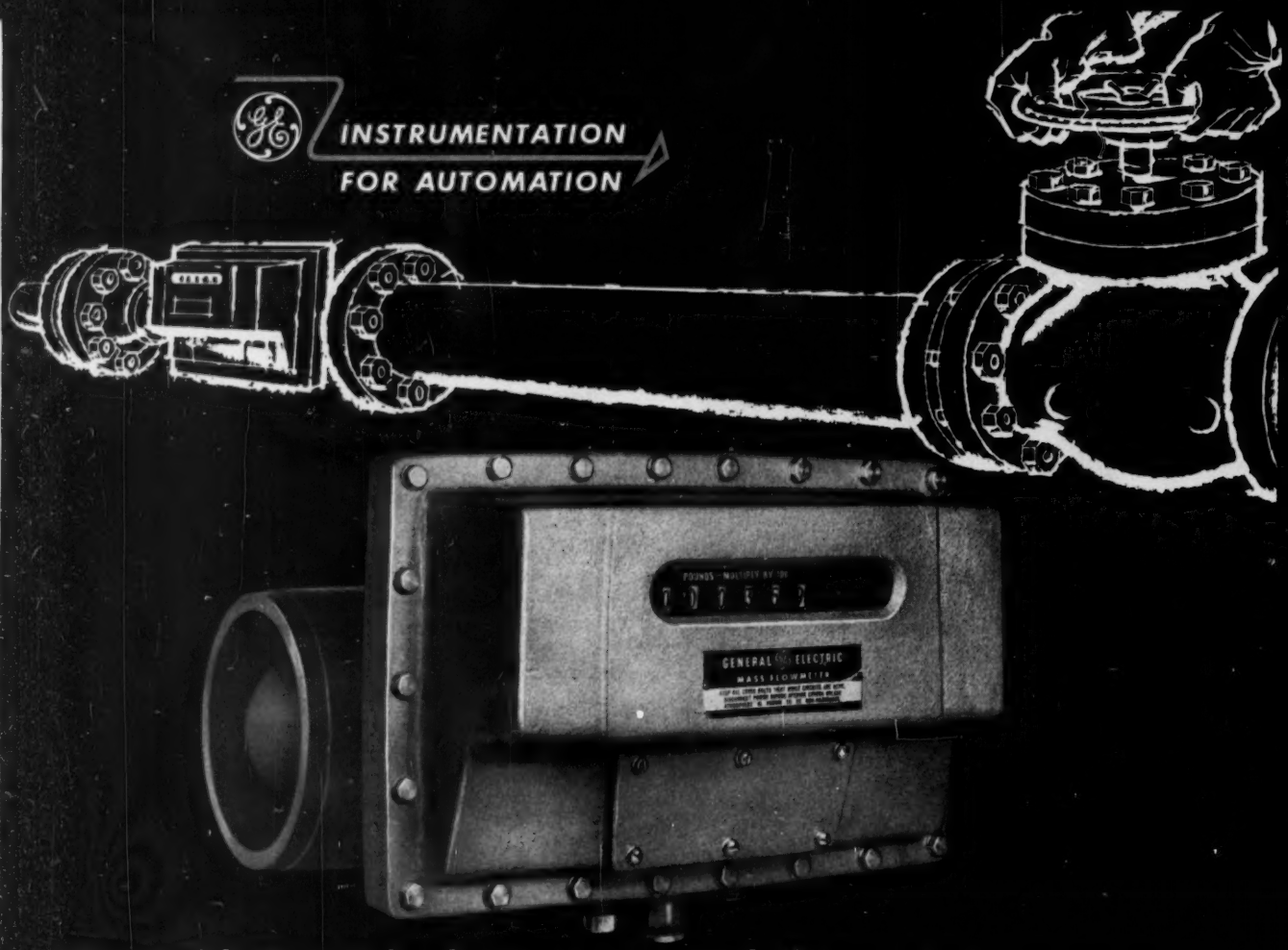
Fig. 3 shows a servo-system which automatically rebalances the thermocouple voltage. The input (bridge) signal is amplified and drives the balancing motor in the proper direction. When the bridge is electrically rebalanced the motor stops. The pen carriage also is linked to the balancing motor.

The principal advantages of the STRANDUCER in a self-balancing potentiometer are (1) the infinite resolution it provides in recording input signals and (2) elimination of the sliding contact. Both are advances of the first magnitude.

Additional networks of resistors provide variations of range so that the circuit can be used not only with thermocouples but also with resistance thermometers, radiation detectors and pH detectors, and for straight millivolt measurement. Electrical instrument spans as low as 1 millivolt are available in all models of the "ElectroniK 17."

Cold-junction compensation for thermocouple measurement is accomplished by adding a third voltage to correct for any change in the cold-junction voltage. This is derived from a temperature-sensitive resistor. The circuit reference voltage is a zener supply, regulated to better than 0.05%. Filtering circuits and a floating shield virtually eliminate the effects of stray signals in the input.

INSTRUMENTATION FOR AUTOMATION



Now, with 12 standard ranges, General Electric Mass Flowmeter

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For example, these 12 applications have been performance-proved in actual service metering:

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(*Many more to come—let us know what your specific application is.*)

NEW ACCESSORIES FOR APPLICATION FLEXIBILITY:

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AND ALL MODELS FEATURE:

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DO YOU HAVE AN APPLICATION for this revolutionary new instrument? Chances are you do, and we'd like to know about it. Contact your nearby G-E Sales Office, or write directly to General Electric Co., Section 599-03, Schenectady 5, N. Y. Be sure to ask for bulletin GEA-6925A. In Canada, contact Canadian General Electric Co., 940 Lansdowne Avenue, Toronto 4, Ontario. On applications in the natural gas industry, contact Black Sivalls and Bryson, Inc., P.O. Box 1714, Oklahoma City, Okla.

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

CIRCLE 59 ON READER-SERVICE CARD

JOURNAL OF THE SOUTHERN CALIFORNIA METER ASSOCIATION

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TOTAL FLOW SYSTEMS

The abrupt inflation in natural-gas prices has increased the importance of accuracy in gas measurement, particularly at points of sale.

LOUIS V. HICKMAN
American Meter Co., Inc.

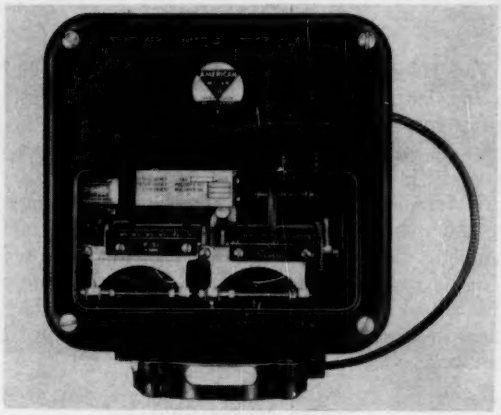


FIG. 1. BASE VOLUME INDEX automatically multiplies each unit volume of gas at pipe line conditions by the pressure and temperature factors, and indicates the quantity of gas passed at base conditions on a counter.

Meeting Notice—Fri. Feb. 25, 1961, Rio Hondo Country Club.
Subject—34th Annual Hi-Jinks will take place at Rio Hondo Country Club on the 25th of the month. A golf tourney will have the SCMA Hi-Jinks Trophy at stake. C. B. McKinney of the Southern Counties Gas Company, Santa Ana, is heading up the Golf Committee.

Our host at Rio Hondo, John Szlavik, promises something special for dinner and Bill Wilson and his Arrangements Committee have assembled "the best show ever" for the occasion. In addition to this being the Hi-Jinks, it is also **Past President's Night** and all of our Past Presidents will be honored guests.

NATURAL GAS is today the nation's fifth largest industry and is growing continually. The price of natural gas has increased from 3 or 4 cents per 1000 cu ft a few years ago to, in some instances, more than 20 cents per 1000 cu ft today. Today's price of gas and the tremendous volumes involved demand accurate measurement.

To the producer of natural gas a "total flow system" means an installation where gas is delivered to the pipeline automatically. A large number of such total flow systems are in service.

In one such installation on the Gulf Coast, the thirteen producing gas wells are in the water. Seven produce from one horizon, and six from another (but at different pressures), and all gas goes to two low-temperature separation units located on a peninsula which is 4½ miles from the mainland. The liquid is extracted on the peninsula and is piped to storage on the mainland. The gas flows through a separate pipeline to land, and then is measured and controlled by a recording flow controller at the point where it is delivered to the pipeline. The measurement here is the total production of all wells; gas from each well also is measured on the peninsula.

This type of installation is unusual in that, as the delivery to the pipeline is varied, each well automatically produces its *pro rata* part and always within its "allowable." Also, no manpower is required offshore to accomplish this; it is only necessary to set the index pointer on the recording flow controller (located on land) to the desired delivery. The resulting change in pressure in the

Presented at The Los Angeles Harbor College, Instrument Short Course, April, 1960.

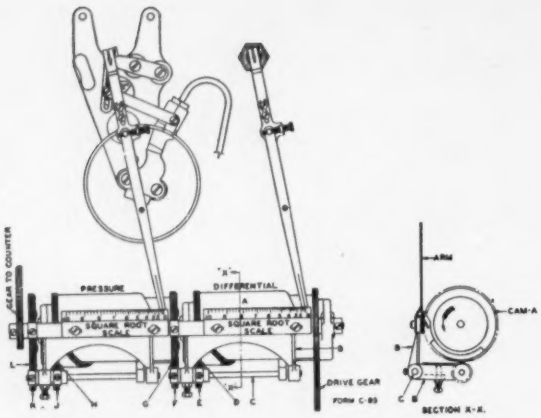


FIG. 2. SQUARE-ROOT EXTRACTION in integrating orifice meter is based on raised cam surface on bakelite cylinders. This model extracts square root of both flow (differential pressure) and line pressure. Output is the product of these two signals.

line from the low-temperature separation units then actuates controls (both pressure and flow) at the separation units, and the change in delivery from each well is automatic.

During certain seasons of the year it sometimes is impossible to use the crew boat for routine inspection of the installation because of rough water, but it is still possible to vary the delivery or even shut down the entire operation in any kind of weather with one man on the mainland.

Distribution

Distribution systems have different requirements. The gas is usually purchased gas and (in many instances) available only within definite limitations. If a certain purchased volume is exceeded, a penalty may be added.

A simple and reliable type of system comprises a positive-displacement meter with Base Volume Index* and Telecount* (Fig. 1). Base Volume Index corrects the meter reading for varying pressure and temperature conditions. The volume measured is totalized on a counter as standard cubic feet, and no computations are required. By using the Telecount with the meter and Base Volume Index, this measured volume can be transmitted over telephone wires to the remote point or dispatcher, where it is totalized continuously on a counter. The Telecount unit has an interlocking circuit which makes it insensitive to vibration, thereby eliminating false counts.

Where the *temperature* can be assumed to be constant (and no temperature correction need be made), a *Base Pressure Index* (with the Telecount unit) can be installed on the positive-displacement meter instead of the Base Volume index. This unit continuously corrects each unit volume of gas at line conditions for pressure; the actual volume at standard pressure conditions is shown without computation.

Integrating Orifice Meter

Where larger volumes of gas are measured than is feasible with the positive-displacement meter, *integrating orifice meters* (Fig. 2) can be used with Telecount. The integrating orifice meter is a standard orifice meter equipped with two bakelite cylinders, each with a raised cam surface, necessary gearing, pressure springs and counter. Normally, operation is electric, but where a-c power is not available a gas-powered "Gasclok" can be used.

The integrating orifice meter extracts the square root of the differential and multiplies it by the square root of the absolute static pressure. The operation of the integrator is continuous, the primary multiplication is performed once a minute, and the sum of the products is totalized continuously on a counter. The difference between the readings obtained at the end and at the beginning of an interval, multiplied by the orifice meter constant, gives the quantity which has passed through the orifice during the interval.

Telecount

The Telecount (Fig. 3), is connected by a shaft to the integrating mechanism of the integrating orifice meter, the Base Volume Index, or the Base Pressure index. It consists of a suitable gear train, magnets inserted in rotating non-magnetic discs, and Mercoid switches. The Mercoids are actuated by the magnets at certain intervals as the non-magnetic discs rotate. As the d-c circuit is closed, a single pulse is transmitted to a remote counter. This signal advances the counter one digit which, when multiplied by the orifice constant, gives the totalized volume.

Duplex Meter Runs

The ratio of minimum to maximum flow of a standard orifice meter or an integrating orifice meter is generally assumed to be approximately 3½ to 1. At city gate stations, industrial installations, etc., where the load variation is greater the 3½ to 1, additional meters and meter runs ordinarily are used.

For instance, the first meter run may use a 10″ and a 100″ duplex meter setting, with only a 100″ meter installed on the secondary meter run. If the distribution system is of such size that telemetering is used, it may be better to use a variation of the integrating meter (which transmits a signal to a remote counter in actual cubic feet).

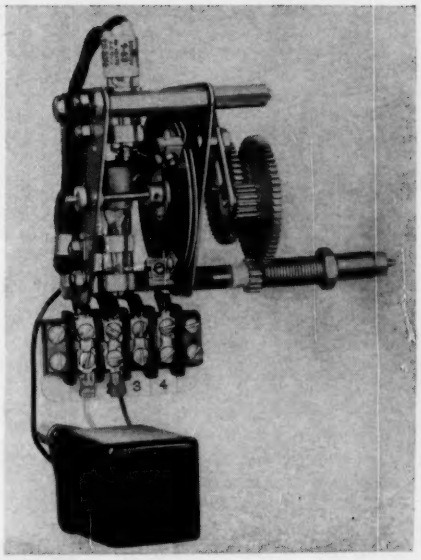
Where a 10″ and a 100″ integrating orifice meter are installed as a duplex setting, the integrating mechanism in each can be provided with suitable gearing and either Mercoid or Micro switches, to

*Registered trade names, American Meter Co.

transmit a signal (pulse) which will represent the same volume from either the 10″ or the 100″ integrating meter. These two signals can be fed into a totalizer. One leg of the telephone circuit then will be used for this signal.

The signal from the second 100″ integrator, also transmitting a signal in actual cubic feet, can use the other leg of the telephone circuit. No totalizer, of course, is required in this instance because only one integrator is involved. These two signals can be transmitted to remote counters or to computing devices at the dispatching office. The integrating meter can, when required, contain a third cylinder (or cam) which applies a factor for flowing temperature, resulting in volume at the selected base temperature.

Where required, this type of installation can be operated on a time-sharing basis with telemetering equipment. When used in such a manner, storage relays are required to store the counts (signals) when the telephone circuit is temporarily used for other functions.



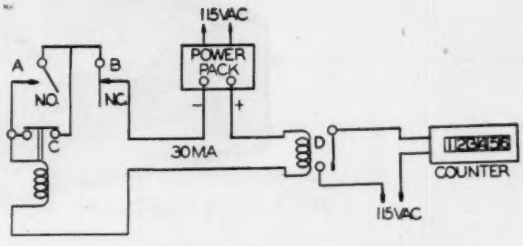


FIG. 3. TELECOUNT and principle. Gear train on orifice meter (or on BPI or BVI) operates mercury switch, which transmits 30-ma signal over 2-wire (or 1-wire and ground) line.

Peak Load Factors

During extreme weather conditions it is necessary that a close check be kept on the volume of gas being used and on the predicted volume for each 24 hours, in order that the contract will not be exceeded. Many companies who purchase gas from pipelines have propane-producing peak sharing plants (manufactured gas plants or underground storage installations) which are placed in service during peak loads to augment the natural-gas purchases. Some companies also pack sections of their systems during off-peak hours when it is definite that the contract will not be exceeded for the 24-hour period.

Many contracts between the gas company and large industries contain an "interruptible clause" which allows the gas company either to cut off the gas to the industry during extreme weather or to curtail supply to a certain percentage of the total volume specified in the contract.

At one power plant in one of our larger cities the interruptible clause limits the volume to 15% of the total during adverse weather conditions. Pressures and flows throughout the distribution system, and from the power plant, are telemetered to the dispatcher, who keeps a close check on operation conditions. In order that the power-plant load can be readily determined by the dispatcher, a flow telemeter transmitter with pressure compensation was installed. Pressure-compensated meters are not new, but the application here is unusual.

The dispatcher can determine readily the instantaneous power plant load, and is able to institute necessary curtailment procedures when required.

The force amplifier used in the pressure-compensated flow-telemeter transmitter has found application also in digital telemetering systems, where it has been used to amplify the power available from a standard pressure spring, for example, to position a shaft encoder. In this manner flow (differential across an orifice), pressure, or temperature can be sensed with a standard sensing element, and the completely mechanical force amplifier is used to increase the power available from the sensing element to a value sufficient to position an encoder. This force amplifier differs from the null-balance type in that an electric motor is used to drive the amplifier, but the input signal is amplified mechanically.

Some installations for *lease automation* in oil and gas production require an instrument to transmit a pulse (representing actual cubic feet) to a multipoint receiver in order to establish gas/oil ratios. Here the integrating orifice meter which transmits a signal in actual cubic feet is used, and its pulse is transmitted to the multipoint receiver. Such installations usually incorporate a strip chart. When no signals are being received, it records straight lines on the chart. As a signal is received, each record on the chart deviates slightly and instantaneously and shows up as a "pip." By counting the pips on the record for gas and for oil (in relation to rate of chart travel), gas/oil ratios can be established.

QUIET PLEASE

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Write for complete details on the new Electronic Associates, Inc. Series 5000 Voltmeters, or call your nearest EAI Engineering Representative.

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CIRCLE 60 ON READER-SERVICE CARD

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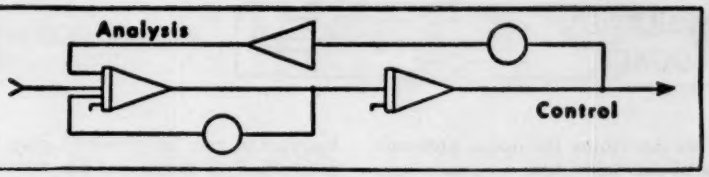

Newsletter

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Suzette McLeod, SECRETARY

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Bits

Added this month is a new feature, "SCI Activities", the purpose of which is explained more fully under that heading.

Also, under **Pieces**, we report what was to your Ed (probably because he's involved in the development and testing of the MAC pump, his own heart-and-lung machine) one of the most interesting meetings he's had the pleasure of attending. This was the July 22 meeting of the Western Simulation Council at UCLA "On the Simulation of Heart-Lung Systems." At this meeting *Ed Deland* spoke on "Mathematical Models of the Circulatory and Respiratory System," *George Bekey* and your Ed made "Comments on Computer Simulation of Physiological Processes," and *Dr. J. V. Maloney* (UCLA Department of Surgery) spoke on "Problems in Human Simulators: The Heart-Lung Machine."

Pieces

WESTERN S/C MEETING OF 22 JULY ON HEART-LUNG SYSTEMS

Dr. James B. Maloney (UCLA Department of Surgery, Los Angeles, California) was host to the July 22nd meeting of the Western Simulation Council held at the University of California Medical Center in Los Angeles. Subject of the meeting was "The Simulation of Heart-Lung Systems."

DeLand on Circulatory Systems

Dr. Ed DeLand (Ph.—not M.D. Rand Corporation, Santa, Monica, Calif.), the first speaker, talked about "Mathematical Models of the Circulatory and Respiratory System" or, more specifically, some work they are doing which has been reported in a U. S. Air Force Project Rand Research Memorandum.*

This project was undertaken to determine the feasibility of simulating a part of the human physiological system by a suitably constructed mathematical model.

Certainly a successful mathematical simulation of the human system or of human subsystems would provide an important tool for biological investigations. A sufficiently complex model —that is, a model embodying sufficient chemical and biological details to represent a whole, functioning human system or subsystem—could be used to explore biological hypotheses, environmental stress reactions, and interplay of dependent subsystems, and could serve as a teaching tool or even an aid to medical diagnosis.

However, the human body may be considered as perhaps the most complicated chemical factory ever devised. It is a dynamic chemical factory in which there are no absolute values.

Therefore, to date, only the techniques, concepts, and characteristics of such a mathematical model have been explored.

Ed's talk concerned a simulation of the external respiratory function. Respiration, and the resulting gas exchanges at the lung surfaces, involve many chemical reactions as well as a transformation of venous into arterial blood. So this activity was chosen for the test case.

Basing their work on the known physiological and chemical aspects of this subsystem, the investigators constructed a mathematical model which, when solved, would give

*"A Mathematical Model of the Human External Respiratory System", by George B. Dantzig, James C. DeHaven, Irwin Cooper, Selmer M. Johnson, Edward C. DeLand, Herschel E. Kanter, and Crawford F. Sams (M.D., University of California); RM-2519; September 28, 1959

GEORGE BEKEY: "We are on the threshold of a breakthrough in biological problems."

values describing the major phenomena of the subsystem. Emphasis was placed on the chemistry and thermodynamics of the subsystem rather than on physical dynamics such as flow and mixing; at this stage these time-phased phenomena were expressed only implicity.

Despite these and other approximations, Ed said that the work shows that the mathematical art is now capable of representing such systems which have large and complex sets of functionally interrelated variables.

The values of some 53 different molecular species, as determined by the model, are in execellent agreement with observed values. There is therefore reason to be optimistic about the possibilities of representing other more complicated human subsystems, and interconnecting them —especially now that mathematical techniques and computing facilities are becoming available for integrating increasingly complicated sets of components. The Rand investigators feel that these techniques should be pushed to the biological or mathematical limit—whichever comes first —in the hope of constructing mathematical models for increasingly large portions of the human system.

Nevertheless, developing a complete and integrated human-system representation is quite a large order. In the first place, the size of medical libraries alone attests to the large volume of special cases which such a model would be required in some sense to interpret. We might nevertheless argue that, with luck and several years of effort by a large number of qualified specialists, it might be possible to handle the task if it were not for one outstanding fact—the great gaps in our knowledge of the human system. For instance, we know the brain plays a major role in the control of the physical processes of the body, but the exact functional relationships that define the control can at best only be hypothesized.

It is precisely in this area that the techniques of simulation provide the scientific investigator with an extremely powerful tool: a tool for testing a variety of hypotheses quickly (once the model is constructed), comparatively economically—and *safely*. Even if the results of such hypothetical explorations at first do not correspond with reality, much useful knowledge can be obtained just in attempting to determine the reasons for lack of correspondence.

And in any case the investigator's insight into the problem is markedly improved.

At RAND it was decided to simulate the external respiratory system on both analog and digital computers.

The *digital computer*, having high accuracy but requiring relatively long solution time, was used to compute the equilibrium conditions of the system and hence to test the underlying hypothesis of the model.

The *analog computer*, with lower accuracy but much shorter solution time, was used to search through a range of parameters. It can also be used eventually, it is believed, to simulate the dynamic aspects of the model. It already has proven itself a valuable tool for tracing the effects of continuously varying inputs to the system. Thus the analog can be used in complex experimental situations for estimating equilibrium constants by regarding these as parameters to be varied continuously on the machine until a good fit is found between observations and predictions.

The advantage of continuous optimization with the analog as compared to the static, one-time optimization with the digital computer is that it can thus compute and display the transient phenomena of a complex system as it changes under the influence of a time-dependent parameter.

Later on, the inputs will be outputs computed from other physiological subsystems, and the whole will be optimized according to viable criteria.

Bekey on Physiological Process

George Bekey (Space Technology Laboratories, Los Angeles, California) followed Ed DeLand's description of the work at Rand with some general comments on the challenge and problems involved in simulating various physiological processes. In this connection he described briefly some work done while he was at Beckman, using the analog computer to simulate nerve excitation.

Geroge also mentioned that when he attended the national ASME meeting in Dallas he found that *Ben Clymer**, of the Human Simulation Subcommittee of the Midwestern Simulation council, was very much interested in this kind of work and has prepared a rather extensive bibliography on the subject.

"We are on the threshold of a breakthrough in the application of mathematical techniques to biological problems," said George, "Because of:

1. The development of mathematical tools for the analysis of nonlinear, time-varying phenomena;

2. The development of instrumentation—micro-electrodes, miniaturized transmitters, and meters for the non-destructive measurement of flow and temperature, for instance. These give us means for verifying the model.

3. The development of methods for the study of closed-loop feedback and control systems.

"Simulation of physiological systems can be divided into three general areas:

a. Simulation of human operator dynamics

b. Simulation of physiological processes (as exemplified by Ed Deland's paper

c. Simulation of higher mental processes: neuron nets, learning machines, etc."

George mentioned some of the work being done but observed that much faster progress could be made except that "Engineers get stumped in studying biology because they run into bio-chemistry. They don't know this, so they have to go back and study organic chemistry (which they skipped in school, because it was hard)."

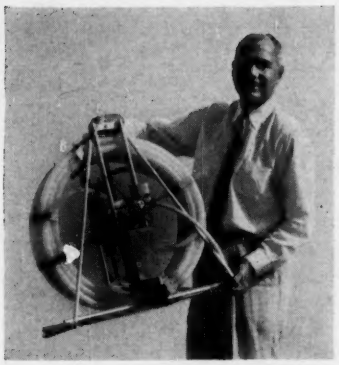
Nevertheless, George convinced most of us that bio-medical engineering is the coming thing, and that computer simulation of the systems involved in an extremely important—and fascinating—part thereof.

McLeod on the MAC Pump

Your Editor followed George with a description of what we hope will be a tangible contribution resulting from the cooperation of medical men and engineers: the MAC (McLeod Aerating Cardiac) Pump.

To those of you who may wonder why a Council member should be

*North American Aviation, Dynamics Development, Department 56, 433 East Fifth Avenue, Columbus 16, Ohio



McLEOD with the MAC pump.

concerned with a heart-lung machine, I can only say that you must take a real broad view; rationalize that because such a machine takes over the duties of the heart and lungs it certainly simulates their function, even if not the organs themselves. Anyway, that's what those who invited me to speak said. So, after much twisting of my arm (ha!), I agreed to talk, and having talked can now write on.

Your Ed first realized the need for cooperation between medical men and engineers when he was at Harvard's Cruft Lab in 1942 and saw doctors struggling with jury-rigged electro-encephalographs which they had to build or modify themselves. But I didn't do anything about it for 16 years, not until stimulated (literally) at a party where some doctors and engineers were discussing a heart-and-lung machine they were building. Intrigued, I asked to see it. And when I did I was impressed. The design was ingenious and the workmanship was beautiful. But something about it bothered me. Finally I realized it was its complexity.

Now your Ed likes simple thinks. Complexity often costs reliability, and it always costs money. "There might not be a better way to build a heart-lung machine, but there *must* be a simpler way!"

That did it! For two-and-a-half years now that "simpler" machine has been competing with your simple-minded *Newsletter* for all your Ed's "spare" time.

To appreciate a solution it is well to understand the problem. In this case I was given to understand that the problem was blood. More particularly, the problem stemmed from the characteristics of blood which had been especially troublesome in connection with all other heart-lung machines: it is delicate, and it foams.

The most dramatic use for a heart-lung machine—or *extra-corporeal perfusion device*, as they are more accurately known—is to take over the action of the heart and keep the body supplied with oxygenated blood during open-heart surgery when the heart itself is incapacitated. Thus the surgeon buys time to make repairs and perform apparent "miracles" which would not otherwise be possible.

The reason that the lung function —that of oxygenating the blood—is included is largely a matter of "plumbing." The heart and lungs are so intimately associated (the lungs being, hydraulically at least, between the two halves of the heart) that it is easier to supply an artificial lung than separate and use the natural areas.

But blood is difficult to handle without damage. It is not a liquid but a slurry, made up of small packages of hemoglobin and other components wrapped in an extremely delicate membrane and suspended in plasma. Pumps which require that valves open and close (or that passages otherwise be occluded) to pump the blood have a tendency to break the packages, destroy their function, and upset the chemistry of the system.

Blood also has a troublesome tendency to foam when it is exposed to the oxygen in the "lung" (aerating) section of the device. This also upsets the delicate balance of the system and furthermore, if any of the minute bubbles are pumped into the biological system they might cause embolism (stoppage) of some small blood vessels. In the brain this could cause damage or even death. In short, it's bad.

There are other difficulties, but I was given the impression that they had been solved, or were unimportant. (How gullible can you get?)

It seemed to me that the "simple" solution was easy. I still think so. But I have spent two-and-a-half years trying to *keep it simple*. It ain't easy. If I may paraphrase:

Simple problems bring other problems

No matter how you write 'em

And these problems get other problems

And so forth, ad infinitum!

The simple solution was this: If a dip in an otherwise gas-filled flexible tube holds some liquid, and the dip is moved along the length of the tube (Fig. 1), the liquid will tend to move

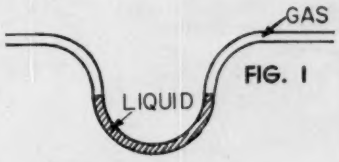


FIG. 1

with the dip. If, however, the end of the tube toward which the dip is being moved is stopped, the liquid in attempting to follow the dip will compress the trapped gas somewhat. And the compressed gas, pushing back, will create a hydraulic "head" across the dip proportional in height to the pressure created (Fig. 2). If, instead

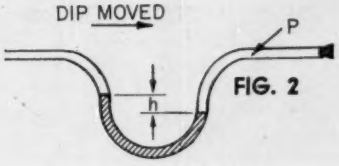


FIG. 2

of one there are several such dips, it can be seen (Fig. 3) that the total

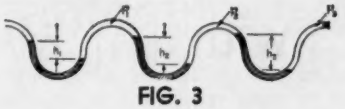


FIG. 3

pressure created will be proportional to the sum of the hydraulic heads across each dip.

Now if the movements of these dips along the tube can be mechanized, the resulting device can be used as a pump. A simple way of doing this, and of supplying new dips as old ones move along, is to wind the tube in a horizontal helix and revolve it about its axis Fig. 4). That, basi-

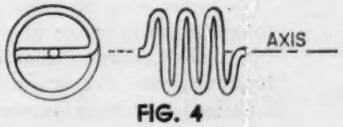
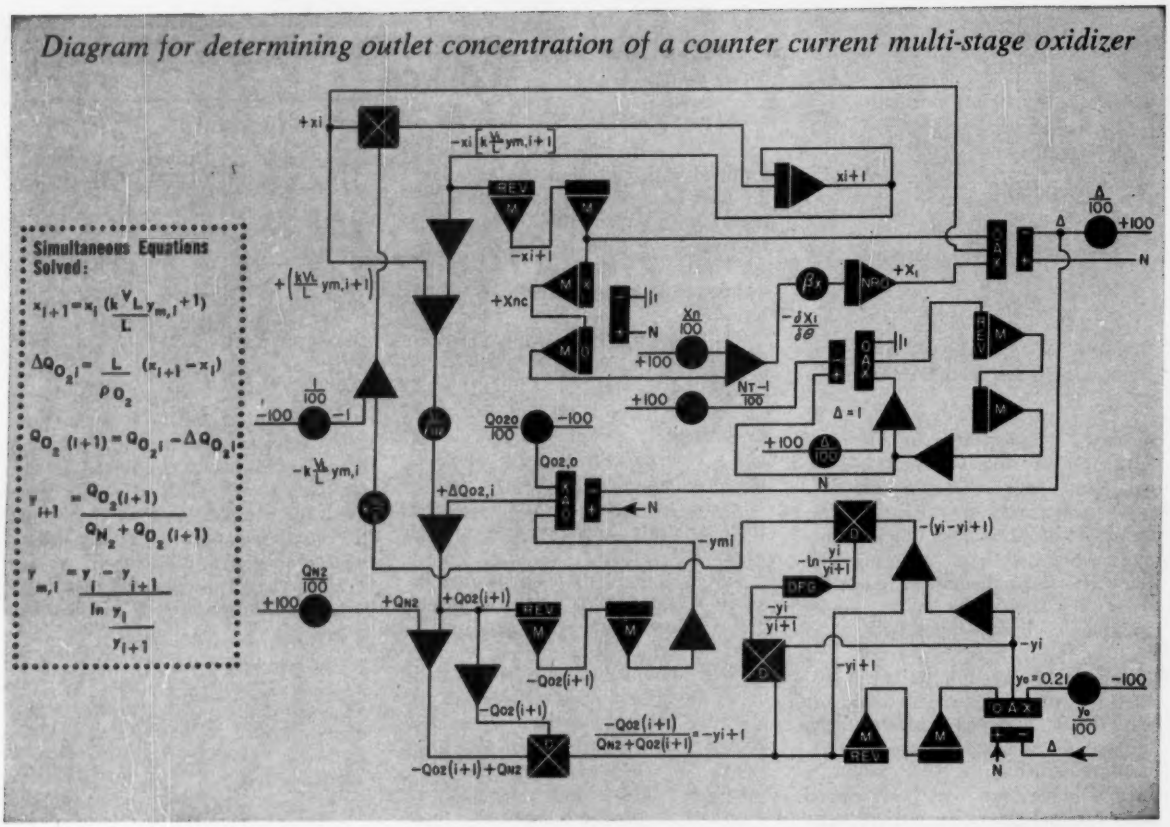


FIG. 4

cally, is the MAC Pump (Fig. 5). Needed are only an inlet for the gas (oxygen) and liquid (blood), an outlet with a float valve to vent the gas while holding pressure on the liquid, rotating points to connect them to the tube, and a motor to turn the helix.

Simplicity! Only one moving part

Diagram for determining outlet concentration of a counter current multi-stage oxidizer



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(other than the drive). No valves (in the blood), no occluding passages, and no fast-moving parts (the helix turns about 10 rpm). No separate "lung." (The lung function is lagniappe." As the top half of the helix must be filled with some kind of gas anyway, the use of oxygen allows the necessary oxygenation of the hemoglobin to take place at the interface with the blood film on the inside of the tubes.) No turbulence to cause foaming. Easy to understand, no special "crew" required. Easy to clean (all parts touching blood can be disposable and replaceable at nominal cost). It is comparatively small, light, and inexpensive (approximately $1000), and (on experimental animals—no people yet) it works!

Maloney on Problems in Human Simulators

The final speaker of the meeting was our host, *James Maloney* (M.D., UCLA Department of Surgery).

Dr. Maloney commended the Western Simulation Council for arranging such a meeting because "we have become so specialized in our own fields that often we don't know or appreciate what is going on in adjacent areas."

Commenting on the vast amount of progress made in the physical sciences using computers and simulation for the analysis and synthesis of complex physical systems, Dr. Maloney remarked (and we will leave it as an exercise for the reader to determine just how seriously), "Physics is passé; medicine is now the frontier science!"

Dr. Maloney went on to back up his remark by pointing out the tremendous scope of medical "worlds to be conquered," the breadth and depth of problems to be solved, and the importance to all of us of getting on with the job.

"We only know," he said, "perhaps 2% of what we should to understand the human system—and we are only able to use perhaps 10% of what we know."

To improve these figures, all possible tools and techniques must be brought to bear, and we in the computer field are certainly in a position to make vital (literally) contributions.

The over-all task is too bewildering for comprehension, but some idea of its challenge may be gathered by considering some of the problems of extra-corporeal perfusion, an area in which Dr. Maloney is much interested.

As we have already stated, there are problems of hemolysis (mechanical damage to the blood) and foaming, but that's only the beginning. Assume for the moment that you have a perfect mechanical device: when that device is connected to and becomes part of a biological system what do you have? The heart-lung machine has only two functions: to pump and to oxygenate. These can be described by three parameters: pressure, flow, and percent saturation. But they are interrelated with each other, not only in the physical but most importantly in the biological system.

For instance, the flow into the biological system is a function of both pump pressure and system resistance. And the latter can and does change in what appears to be an arbitrary manner.* So what do you control? Pump pressure? Keep the flow at the desired rate? Keep arterial pressure at a pre-selected level? Or hold a constant venous pressure?

And what of oxygenation? Is it possible to over-oxygenate? Hyperventilation (deep breathing) in vivo (in the normal body) can cause dizziness. Under some conditions (under water, for instance) breathing pure oxygen can cause oxygen narcosis. Are we liable to do this to our patients? If so, it is dangerous? Just what is the mechanism of oxygen narcosis anyway?

And how about CO_2 removal? This is as much a function of normal breathing as O_2 uptake. If the CO_2 formed by burning oxygen in the biological system is not removed, the pH (acidity) of the blood goes down and the entire chemical balance is upset.

These are only a few of the many things we would like to know more about. Yet they are selected from a very specialized area in which, surprisingly enough, the doctors (with some assist from engineers, of course) have performed miracles. How much better could they do here if we could help them get more answers? And how many "miracles" could they perform that are only dreamed of now.

It's *our* ball!**

*Of course it isn't, but I have to find anyone who can predict or control it! —Ed.

**In this case "having a ball" is real serious business!—Ed.

After his talk Dr. Maloney introduced the engineer of his group who is in charge of their heart-lung machine.

The UCLA machine, assembled from "off-the-shelf" basic components, has some interesting features of convenience and control. However, the pumping is accomplished by perhaps the most popular type of pump, and the oxygenation by one of the most popular oxygenators.

The pump is a section of elastic tubing held in a semi-circle by a stationary backing, while two rollers on opposite ends of an arm rotating about its center(which is concentric with the center of the semi-circle) compress the walls of the tubing to force the blood in the direction of rotation.

The "lung" consists of a series of discs housed in a horizontal cylinder and turning about a common axis so that they dip into blood flowing through the bottom of the cylinder. As the discs turn, this creates a film which in the upper section of the cylinder is exposed to oxygen and oxygenation of the hemoglobin takes place.

This device was demonstrated to the group. It was pumping water instead of blood, and there was no "patient." Nevertheless, the demonstration was interesting—and probably just as realistic as many of the group would like it to be!

Computer Events

★ **Midwestern S/C meeting—Jan. 16, 1961**

Allison Div., (Plant 8), General Motors Corp., Indianapolis, Ind. Topic; "Novel Solutions to Nasty Problems"

★ **Southeastern S/C Meeting—Jan. 27, 1961**

Georgia Institute of Technology, Atlanta. Topic: "Moving Average" and "Medical Research" plus other papers.

★ **AIEE-IRE-ACM**
Western Joint Computer Conference

Ambassador Hotel
Los Angeles, California
9-11 May 1961

SIMULATION COUNCIL

SCI Activities

In the past it has been your Ed's practice (if indeed he can be said to have had a practice) to put all info pertaining to a particular Simulation Council meeting into a suitably labeled folder. Then when all info appeared to be in, I would "edit" the material, in more or less chronological order, and come up with a *Newsletter* of sorts. This meant that meetings which were not properly reported would probably *never* even be mentioned.

This isn't in line with our objective. The purpose of this N/L is to keep you informed as to what is going on, even if we can't give details. So henceforth we are going to report meetings and programs as soon as we get the info. We will then, as in the past, report interesting and/or significant details under *Pieces*—if and when such details are forwarded to us by the responsible Secretaries of the individual Councils.

This month, to catch up, we are going back nearly a year to pick up meetings, or individual presentations at partially-reported meetings, not heretofore mentioned.

CENTRAL S/C meeting: 22 February 1960 at Humble Oil & Refining Co., Baytown, Texas, on "Chemical Process Problems"

Scheduled talks:

"Dynamic Response of a Thermocouple" by **Francis X. Meyer** (Esso Laboratories, Baton Rouge, Louisiana)

"Thermal Stress Analysis of Exchanger Tube Sheets on an Analog Computer" by **D. G. Killough** (Humble Oil & Refining Company, Baytown, Texas)

"The Application of Analog Simulation to the Statistical Design of Experiments" by **Joseph F. Paul** and **Paul E. Parisot** (Monsanto Chemical Co., St. Louis, Missouri)

"Optimization of the Finite Difference Lattice Structure for Diffusion Processes" by **M. L. Gilliland** (Beckman/Berkeley Computing Center, Los Angeles, Calif.)

DR. MAX GILLILAND

"Simulation of a Fixed Bed, Non-Isothermal Chemical Reactor Using Dynamic Analog Memory" by **E. A. Clarke** (Humble Oil & Refining Co., Baytown, Texas)

"Equations Encountered in Heat Transfer Problems" by **Eric Liban** (Pratt Institute, Brooklyn, New York) and **R. K. Stern** (Computer Systems, Inc., Monmouth Junction, New Jersey)

I heard several enthusiastic reports on this meeting, but somehow nothing printable (or unprintable, for that matter) ever reached me. So unless some of the individual speakers should at this late date care to send me info on what they said, it will, insofar as these columns are concerned, be lost forever. *C'est la vie d'éditeur*!

CENTRAL S/C meeting: 23 May 1960 at Boeing Airplane Company, Wichita, Kansas

The technical program consisted of:

"Noise: Its Definition and Measurement in Analog Studies" by **Don C. Augustin** (McDonnell Aircraft Corp., St. Louis, Mo.)

"Maintenance of Analog Computers" by **Frank Gorn** (Monsanto Chemical Co., St. Louis, Mo.)

"Patching Circuits Helpful in Preventive Maintenance" by **Richard Kraus** (Beech Aircraft Corp., Wichita, Kansas)

"Preventive Maintenance: Techniques, Scheduling and Administration". This was a panel discussion moderated by **T. R. Herndon** (Humble Oil & Refining Co., Baytown, Texas). Panel members: **Augustin, Gorn,** and **Kraus.**

As in the case of the CS/C's February meeting, we're sorry that we have no further info on this later meeting to record for posterity.

SOUTHEASTERN S/C meeting: 17 June 1960 at Auburn University, Auburn, Ala.

Scheduled talks:

"Comparison of Analog Computer Analysis and Experimental Data of a Feedback Control System" by **W. M. Feaster** (Department of Electrical Engineering, Auburn University)

"A Mechanical Analog of an Electrical Impedance Bridge" by **H. M. Summer** (Department of Electrical Engineering, Auburn University) and **James Sherman** (Autonetics Division, North American Aviation, Downey, Calif.)

"An Analog Method of Determining Frequency Response" by **John Webster,** (Chrysler Missile Division)

"Synthesis of Antenna Arrays with an Electronic Analog Computer" by **H. M. Summer** (Department of Electrical Engineering, Auburn University) and **George M. Peace** (Assistant in Electrical Engineering, Auburn Research Foundation)

"An Analog Approach to the Solution of Nonlinear Problems with the Number Series" by **C. H. Weaver** (Department of Electrical Engineering, Auburn University)

Thanks to *Jim Tootle*, the Southeastern Simulation Council's Secretary, we are in somewhat better shape on this one. We mentioned the *Weaver* paper in the October 1960 Newsletter and the Summer-Peace paper will be covered in its entirety in an early issue.

He Went Thataway!

Sidney J. Korn (formerly Secretary, new Chairman of the Eastern SC) to Loral Electronics Corp., 825 Bronx River Avenue, New York 72, N. Y.

Will report other SCI activities next month.

International Electrical Standards Laboratories

DR. JAMES B. KELLEY

Physics Research Laboratories, Inc.

Impressions gained from visits to, and work with, the national standards laboratories of the USA (National Bureau of Standards), Great Britain (National Physical Laboratory), West Germany (Physikalisch-Technische Bundesanstalt-Berlin and -Braunschweig), France (LCIE) and Austria (Austrian Bureau of Standards); and also the Bureau International des Poids et Mesures. There is great need for better exchange of information between these laboratories and their personnel.

THE BUREAU INTERNATIONAL DES POIDS ET MESURES, located in a former private estate which surrounds a rectangular courtyard in the Paris suburb of Pont de Sèvres, and staffed by a dozen Frenchmen, carries out the basic physical measurements of length, mass and time that correlate most of the standards laboratories of the world. It is also the central international agency where certain electrical and optical measurements are made on a comparative basis. At regular intervals, several years apart, the various countries of the world send their own national standards to the International Bureau for intercomparison.

In the electrical field, the unit of greatest interest is the *ohm*. There is no "standard ohm" any place in the world. There are merely many 1-ohm resistors made according to the specifications of national laboratories which exist in the different countries.

The 1-ohm resistors are hand-carried to the International Bureau, where they are intercompared. The procedure by which this is done is refined and involves many cross-checks and corrections. Essentially it breaks down to the measurement of these 1-ohm standards by a bridge method where the bridge is built-up of individual components of rather considerable age and hence highly reliable stability. After all readings have been made and refined, an average is taken and each resistor compared to the average. If any resistor or group of resistors from a particular country is seriously off in its value from the previous test or from the group, then that resistor or group may be excluded from the average, and the country which submitted the resistor will be notified.

According to those in charge of this work at the International Bureau, a good 1-ohm resistor will not vary more than 1 or 2 parts in a million from test to test.

The procedure from this point back to the national bureau in a given country is to use these 1-ohm standards as the primary resistance standards, and to make all further measurements from these. The practice at the national bureaus is to intercompare these resistors with additional 1-ohm standards, and thereby follow the method of the International Bureau internally. From the 1-ohm standards, other resistance values are measured. Of course, it can be seen at once that, quite aside from the fact that the ohm has never been rigorously established in terms of the basic physical quantities, there is the chance for the introduction of errors every time a new measurement is made. While the errors might conceivably be compensatory, the view must be taken that they are additive. The problem is something like sawing ten pieces of wood where only the first piece was measured and then each successive piece is measured from its predecessor. The certainty of the measurement is diminished as the successive measurements are made.

It is for this reason that the National Bureau of Standards in the United States will *read* a standard resistor to the nearest part in a million, but will *certify* it only to 20 parts in a million. Actually, both NBS and the International Bureau are measuring the resistor's variation with time, or its *stability*. There is not much else that can be said about the resistor's value because no one has yet offered a rigorous definition of the ohm in terms of previously defined dimensions or constants.

The measurement heart of the world. (Courtesy the International Bureau of Weights and Measures, France.)

Comparison of Laboratories

The national standards laboratories in the United States, Great Britain, West Germany and Austria are similar in organizational set-up. In France, however, there is a somewhat different arrangement. Whereas in the first four countries the national laboratories are government operated, in France they are privately operated as non-profit organizations supported by the appropriate industries. Each area of interest has its own facility which is administratively and physically separate from all others. The organization concerned with electrical measurements is the *Laboratoire Central des Industries Electriques.*

Perhaps the two national laboratories most similar, even in general physical appearance, are the National Bureau of Standards and the National Physical Laboratory (NPL) in Teddington, England. The principal differences are internal administration and separation or combination of responsibilities.

In West Germany there are two standards laboratories—the Physikalisch-Technische Bundesanstalt-Braunschweig and the Physikalisch-Technische Bundesanstalt-Berlin. The Braunschweig unit is the main office and is also the oldest national standards laboratory in the world, while the Berlin bureau is confined principally to work for West Berlin. However, the PTB-Berlin is very large because West Berlin is the center of a large part of the German instrument and scientific apparatus business for all of West Germany. Hence the services of PTB-Berlin are much in demand.

The Austrian Bureau of Standards is somewhat smaller than the others, but is well equipped and capable of precision comparable to that of the laboratories in larger countries. Because of a law in Austria which requires that all watthour meters be government-approved before they can be installed in homes or buildings, the Austrian bureau is deeply involved in watthourmeter calibration. Although this is a burden, it is also a source of income.

Research

Research is pursued at all the national bureaus and at the International Bureau. In October 1960, the International Bureau announced that its old plantinum meter standard had been replaced by the wave length of the orange-red light of Krypton-86. The new definition of the meter is 1,650,763.73 wavelengths of Krypton-86 light. With the former standard an accuracy of 1 part in a million parts of an inch could be attained. The new standard improves this by a factor of 100—that is, 1 *part in* 100 *million parts of an inch.* The pressure for this greater accuracy comes to a great extent from the space vehicle and satellite fields. Here even an error of a millionth of an inch can cause a moon shot, for instance, to miss by 1000 miles.

The International Bureau also is working to improve the 1-ohm standard. The approach taken uses a 1-ohm resistor made from platinum and maintained at the temperature of the triple-point of water. The project was started about three years ago and, according to the investigators working on it, shows promising re-

PTB-Berlin, Siemens Building

sults. A similar project was undertaken at NPL several years ago but abandoned because of instability problems.

At NBS, NPL and the Austrian National Standards Laboratory, another joint project is under way in connection with the *definition of the ohm*. This project has as its primary object the definition of capacitance to a degree not formerly thought possible. The work has been extremely successful to date and promises that capacitance can be set with a precision of 1 part in a million, *and measured with an accuracy of* 1 *part in a million.*

While the capacitance approach to a better definition of the ohm is being pursued by NBS, NPL and NSL, the traditional inductance method of defining the ohm is being studied for further improvement at NBS and LCIE (the French organization). The feeling among staff members of both laboratories is that all reasonable approaches to the problem should be pursued simultaneously, so that the final method will have the advantage of independent checks and independent thinking. As one French physicist put it, "It would be most unwise to ignore any rational approach." At LCIE, studies have also been initiated for defining basic electrical quantities using nuclear methods, particularly proton moments. This work is still in an early stage.

A-C Measurements

While the researches in *direct-current measurements* are pushing closer to a goal of a part per million accuracy, work in *alternating-current* measurements, except for capacitance and inductance, lags some 100 times behind. The difficulty of fixing standards in direct current is small compared to the difficulties found in alternating currents, and these difficulties mount rapidly as frequency increases. If the further requirement of portability is imposed, then the problems become even more severe. At present, there is no national laboratory in the world which feels it is capable of measuring either alternating current or voltage to an accuracy of 0.01% with sufficient assurance to make a claim for such accuracy. At NPL, where an extremely elaborate electrometer method is employed, it is felt that under carefully controlled conditions and with due consideration for all variables involved, an accuracy of 0.05% for voltmeters, ammeters and wattmeters of suitable design can be *certified*. NBS also limits its certification to this 0.05%.

One interesting and important project under way at NPL is the design and development of *high-frequency current* and *voltage transformers* which show accuracies of the order of 50 parts per million and better over a wide range of currents, voltages and frequencies. Such transformers have been built and tested, and reports of the results soon will be appearing in the literature.

Simultaneously, at NBS in Washington, research continues on *thermocouple-type instruments* which, it is expected, will make an accuracy of 0.01% possible for at least current and voltage measurements through the audio range. Progress to date is encouraging.

One final impression gained from visits to these laboratories and from continued work with several of the national laboratories, is that there is a clear need for a better exchange of information among the national laboratories of the world. It is surprising to find out how much more could be known by all the laboratories about the work of the others. Due to the extremely limited and closely watched budgets of all the national laboratories, personal visits are few and of short duration.

In addition, the fact that the United States is not a subscribing member of the International Electrical Commission offers some further difficulties. The IEC is working hard towards an international standardization of accuracy definitions and limits—a project which should be given the most sympathetic understanding possible in the United States. Increased and continued cooperation among standards laboratories can do much to clarify the reasonable limitations which must be placed on basic standards, and the secondary developments of these standards.

USSR

Although a visit to the Soviet Union was impossible, a friend who serves on the International Electrical Commission supplies the following information about standards work in the USSR:

The government agency in direct charge of all standards is the *Institute of Metrology* at Leningrad. As in the United States and West Germany, there are branches of the Institute in other cities—a necessity in so large a country as the Soviet Union. The Soviet Union is represented on the IEC and regularly sends its basic standards to the International Bureau for comparison with those of other countries. These standards compare favorably with those of the West. Other Eastern European countries also serve on the IEC and submit standards for intercomparison. The German influence is said to be particularly strong in Soviet instrument design, and the Soviet also purchases either directly or through its satellites many instruments from West Germany. The head of the Institute of Metrology holds the title of Professor (in all of Europe, both East and West, the highest intellectual title one can hold), and he has been a recognized leader for many years in the field of electrical instrumentation. Thus, it appears that the Soviet Union is both capable of and interested in promoting better measurements. From exports being delivered to the USSR, from trade fairs and from technical meetings, there is every reason to believe that the Soviet Union is working just as hard and just as intelligently in basic measurements as are its Western rivals.

HOW SHOULD YOU EVALUATE POTENTIOMETER ACCURACY?

Accuracy in an instrument is more than a matter of how closely measured values correspond to true values. Some potentiometers, for example, may be capable of sky-high accuracy—but only under ideal laboratory conditions. Other potentiometers may deliver consistent high accuracy . . . higher than you actually need . . . with the penalty of excessive cost.

A realistic evaluation of potentiometer accuracy, then, involves consideration of stability and reproducibility as well as stated limits of error. By these criteria, Rubicon potentiometers, galvanometers and bridges should be YOUR choice.

By any measure, the new Rubicon 2746 *portable* potentiometer is an outstanding instrument. Ranges 0—1.601 and 0—0.1601 volts. Limits of error are constant, realistic, usable: high range—30 microvolts or 0.03% of reading, whichever is larger. Low range—3 microvolts or 0.045% of reading, whichever is larger. Depend on it for *consistent* accuracy. **Write for Specification Sheet RS-2746, for details.**

Rubicon accuracy stems from a long tradition of engineering excellence and a pride of craftsmanship that is not easily found these days. You can sense this about Rubicon instruments, even before you put them to work. And today the Rubicon tradition of the finest in measuring instruments is being perpetuated by both small refinements and major advances in design . . . to make the best even better. The complete line of Rubicon instruments is available through any of the Honeywell branch offices across the nation.

MINNEAPOLIS-HONEYWELL, Rubicon Instruments, Ridge Ave. at 35th Street, Philadelphia 32, Pa.

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Instrument Accuracies

This discussion defines the different types of instrument accuracies —namely, electrical accuracy, tracking accuracy, linearity and repeatability, primarily directed at d-c indicating instruments.

GERALD STOLAR
Daystrom, Incorporated
Weston Instruments Division

THE DEFLECTING TORQUE produced in a d-c instrument is proportional to the product of the flux density in the instrument air gap (B), the current passing through the moving coil (I), and the number of turns on the moving coil (N). That is:

$$T = KBIN$$

The first term that needs defined is the term "error." An error is any effect, condition, or phenomenon that causes a difference between the actual current or voltage as read on a standard, in comparison to the indicated value read off the scale of the instrument. The equation discloses that errors could be caused by variation in the characteristics of the torque spring, the flux density distribution within the air gap, and the number of turns actually wound on the moving coil.

Errors also are caused by variations in (1) the mechanical construction of the instrument, (2) conditions such as temperature, stray magnetic fields, and magnetic mounting panels, (3) mishandling due to mechanical shock and electrical overload, and (4) exposure due to extreme environmental service conditions such as vibration, temperature, shock and humidity.

Magnitudes of these errors are a function of the individual instrument design, both mechanical and electrical, and the quality of the workmanship.

Specific errors are as follows:

1. FULL-SCALE ERROR

"Full-scale error" exists if the actual full-scale current or voltage differs from the rated full-scale current or voltage of the instrument. Variations from design value for the parameters in the equation defining torque of a moving-coil movement make it necessary to treat or "pull down" the flux density of the magnet in order to meet and maintain the accuracy requirement. These variations typically are caused by necessary manufacturing tolerance for spring torque, flux density, and turns on the moving coil.

2. BALANCE ERROR

Balance error exists if the pointer moves when the movement is rotated. The moving element of pivoted instruments is supported on jewel bearings which provide a low-friction support. Necessary static balancing of such a system is accomplished by the use of adjustable balance weights along two mutually perpendicular axes. Since the balancing operation cannot be mechanically perfect, some error will exist.

3. FRICTION ERROR AND ROLL

The turning action of the pivots in the jewel bearing causes some friction, which is apparent as a reading error in an instrument having a relatively low torque-to-weight ratio. The friction acts as a retarding torque, and can be eliminated by tapping the instrument lightly. When instruments are used in a vertical position, there is a tendency for the pivot to roll up the side of the jewel. This yields an additional error known as *roll*. Roll is also a function of torque-to-weight ratio and can be eliminated by lightly tapping the instrument.

FEBRUARY MEETING—Michael's Restaurant (Dinner $4). Feb. 1. Speaker—Dr. R. Bouche of Endevco Corp., will speak on "Force, Vibration and Shock Measurements."

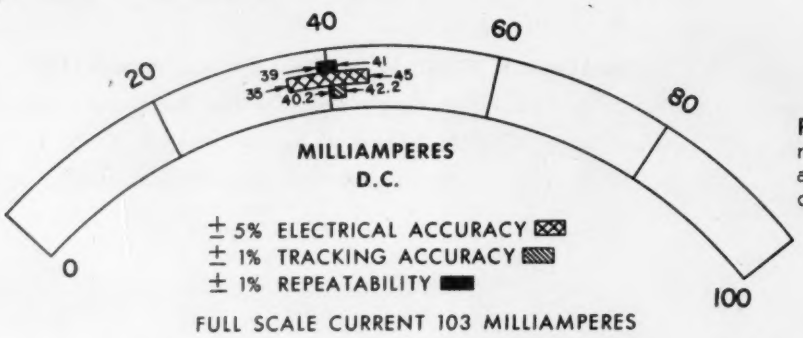


FIG. 1. SCALE for a 100-ma meter with ±5% electrical accuracy, ±1% tracking accuracy and ±1% repeatability.

4. SCALE ERROR

Scale data is obtained by applying fixed values of current or voltage to a group of instruments and measuring the resulting angular deflection. The angular deflection for a fixed current or voltage will vary as much as two degrees from instrument to instrument. The printed scale is designed by computing the *average* angular deflection for each cardinal point for the group of instruments tested. Therefore, all production instruments will not match the markings of the printed scale exactly, and any differences are known as "scale error."

5. SPRING-SET ERROR

Springs deflected for extended time intervals may not return to the original zero position when current is removed. "Spring-set error" is a characteristic of the instrument spring, and is sometimes referred to as *mechanical hysteresis*. After several hours a pointer will normally return most of the way to zero. This indicates that the spring-set error is composed of both a temporary-set error and a permanent-set error. The temporary-set error is usually at least four times as much as the permanent-set error, the exact ratio being a function of the type of spring material, the angular deflection, and other factors.

6. MAGNETIC ERROR

Magnetic error, caused by impurities located within the moving element which are magnetized by the instrument magnet, acts like hysteresis in that readings taken by deflecting the pointer upscale will differ from readings taken by deflecting the pointer downscale. This type of error is most apparent in instruments of low torque-to-weight ratio and relatively high air-gap-flux density.

7. TEMPERATURE ERROR

Instruments will exhibit a "temperature error" whose magnitude is a function of each particular instrument. Both the torque spring and the magnet are affected by temperature. The spring will decrease in torque with an increase in temperature whereas the magnetic flux will decline with increase in temperature. These two effects are partially compensating regarding their effect on the current required to produce a given deflection.

8. FALL-OVER ERROR

In any instrument there must be a fixed mechanical clearance between the dimension over the pivot extensions of the moving element and the dimensions between the pit of the jewels. This is necessary in order to avoid binding of the moving element. Depending on the amount of this clearance, or end play, the moving element can tilt in jewel; this will show up as a mechanical error which is designated *fallover*. With proper jewel settings this error can be kept to a minimum.

9. EXTERNAL-FIELD ERROR

Magnetic fields emanating from any source can alter the flux distribution and magnitude within the mechanisms air gap, causing an "external-field error." Instruments using core-magnet mechanisms are practically immune to the effects of external fields because of inherent self-shielding. The external field error is generally a temporary effect in that removal of the magnetic field eliminates the error. However, large external magnetic fields can produce a permanent instrument error.

10. MAGNETIC-PANEL ERROR

Unshielded instruments will be affected by the proximity of a magnetic panel due to the change produced in the stray field pattern of the instrument magnet. This "magnetic-panel error" can be compensated by calibrating the instruments when mounted on the specified panel.

Accuracies

The various accuracy terms can be defined according to the instrument errors discussed. When performing accuracy tests, there are certain standardized conditions that must be specified. They are a function of both the type of instrument being tested and the end application. The manufacturer has a standard practice which defines these conditions as follows:

a. Panel and switchboard instruments shall be tested with the plane of the instrument window in a vertical position, unless otherwise specified.
b. Portable instruments shall be rested with the plane of the instrument window horizontal, unless otherwise specified.
c. Instruments shall be set on zero with the zero adjuster preceding each set of readings, unless otherwise specified.
d. Instruments should be lightly tapped before taking each reading unless otherwise specified in the individual test requirements.

e. Unless otherwise specified, a minimum of 6 meter readings shall be taken at approximately equally distant marked points on the scale, including the zero position and full-scale position.
f. Standard instruments used for tests shall be periodically calibrated. Readings taken during each test shall be corrected for standard instrument errors, unless they can be considered negligible.
g. Unless otherwise specified herein, all tests shall be conducted at a reference temperature of +25°C, ±2°C.

The different accuracy terms are defined as follows:

1. ELECTRICAL ACCURACY

The "electrical accuracy" of an instrument is expressed as a numerical tolerance in terms of percent of rated full-scale value. Electrical accuracy is the ability of an instrument to indicate at the division line being checked when energized by the corresponding rated value of current or voltage, plus or minus the product of the accuracy rating times the full scale rated value. All the errors described are not necessarily present in each and every instrument. Those that are combine to form a composite error which must be within the electrical accuracy tolerance established for the particular instrument in question.

American Standards Association Specification C39.1 governs requirements for commercial electrical indicating instruments. Aside from the electrical accuracy requirement, the specification defines limits for some of the errors discussed. These limits are designated as "influences" and are expressed as a numerical tolerance in terms of percent of rated full-scale value. Errors that essentially fit this category are, specifically, balance error, spring set error, temperature error, external field influence error, and magnetic panel error.

Fig. 1 shows a scale for an instrument having a 0-100 milliampere range and a ±5% electrical accuracy. This means that the instrument is within the electrical accuracy requirement of ±5% if it indicates at the 40-milliampere division line with the application of a current within the range 35-45 ma.

2. TRACKING ACCURACY

Tracking accuracy for an instrument is expressed as a numerical tolerance in terms of percent of actual full-scale value. Tracking accuracy is the ability of an instrument to indicate at the division line being checked when energized by corresponding proportionate value of actual full-scale current or voltage plus or minus the product of the accuracy rating times the full-scale actual value. A proportionate value is defined as the product of the actual current or voltage required to deflect the pointer to the full-scale division line times the ratio of the rated scale value being checked to the rated full scale value of the instrument.

That is, if V is the rated value of current for any division line, F the rated value of current at full scale deflection, I the actual value of the full scale current, and T is percent tracking accuracy, then tracking accuracy tolerance range at checked scale value equals

$$(V/F)\ (I) \pm (T) \qquad (1)$$

By this definition, tracking error can consist of all the errors discussed with the exception of "full-scale error" because the actual value of full-scale current or voltage is measured. When performing a tracking-accuracy test, the instrument should be carefully set on zero with the zero corrector. Therefore, tracking errors for both the zero setting and full-scale setting of the instrument are meaningless; the former is set for no error, whereas the latter is measured for actual value.

As an example, the instrument in Fig. 1 has a ±1% tracking accuracy requirement, a ±5% electrical accuracy requirement, and a full-scale current of 103 ma. Substituting these instrument values into the above equation shows that tracking accuracy tolerance range at 40 ma is:

$$(40/100)\ (103) \pm (0.01 \times 103)$$

This reduces to a value of 41.2 milliamperes ±1.0 milliampere. As depicted on the scale presentation, this means that the instrument is within the tracking accuracy requirement of ±1% if it indicates at the 40-milliampere division line with the application of a current within the range of 40.2 to 42.2 milliamperes.

The test for tracking accuracy is performed on indicating instruments using the actual scale specified, whether it be a commercial scale or a custom configuration.

3. LINEARITY

The linearity or deviation of an indicating instrument is identical in definition to that of tracking accuracy, except that the test itself is performed with an instrument having a mechanically uniform, angularly divided scale. It is also expressed as a numerical tolerance in terms of percent of actual full-scale value.

Linearity is a measure of the instrument's degree of departure from a mechanically uniform, angularly divided scale. It is a design characteristic fixed for a given mechanism and a function of the magnetic system's mechanical construction. It therefore should not be considered as a variable.

4. REPEATABILITY

Repeatability accuracy of an indicating instrument is expressed as a numerical tolerance in percent of actual full-scale value. Repeatability accuracy is the ability of an instrument to repeat its readings taken when deflecting the pointer upscale by the reading taken when deflecting the pointer downscale. The current or voltage obtained by deflecting the pointer downscale to the division line being checked should equal the current or voltage obtained by deflecting the pointer upscale to the division line being checked plus or minus the product of the accuracy rating times the full scale actual value.

Repeatability specifically measures the composite error caused by friction or roll, spring set, magnetic impurities, and fall-over. In order to include the friction error, the test is performed by setting the pointer to the division line with no overshoot and without any tapping.

As an example, let us assume the instrument in Fig. 1 indicates 40-milliamperes with a 40-ma applied current, going upscale. Then the instrument is within the repeatability requirement of 1% if, going downscale, it indicates 40-milliamperes with the application of a current within the range of 39.0 to 41.0 milliamperes.

NRC—Counterpart of NBS

MARVIN STEINBERG

Sensitive Research Instrument Corporation

Equal validity can be attached to either an NBS or NRC certification or report. This offers manufacturers of precision instruments an important alternate source for certification demanded by purchasers.

CANADA, England, Australia and other countries operate and maintain excellent national standards laboratories. However, specific information concerning the capabilities and policies of these organizations has not been made readily available in the United States. Such knowledge is not only of academic interest; it is of importance to the purchaser of imported equipment who desires to obtain quality assurance testing prior to shipment from a foreign supplier. (This is often a worthwhile procedure in view of the time and expense involved in bringing equipment into this country.) In particular, not enough publicity has been given to the fine standardization of the National Research Council (NRC) in Ottawa, Canada, which deserves special attention because of (1) its proximity to the United States and (2) the recent modification of the Buy American Act for certain classes of equipment originating in Canada, which was prompted by a Congressional desire to broaden our mobilization base.

When Sensitive Research Instrument Corporation started to market "COMMANDER" instruments,* it was faced with the problem of showing traceability to the National Bureau of Standards in either Washington, D. C. or Boulder, Colo. As NBS operates with limited funds and personnel, this would have imposed on NBS facilities a large additional work load in the form of Guildline equipment, whose purchasers would in most cases demand NBS certification. As a result, Sensitive Research contacted Dr. Chester H. Page of NBS, requesting information as to whether it would be feasible for Sensitive Research to provide NRC Test Reports where customers required an outside calibration service. Dr. Page answered the inquiry and noted that, from a technical standpoint, there should be *equal validity attached to either an NBS or NRC certification or report.* This letter of high significance points out (1) it is up to the user of the equipment to determine whether or not to accept an NRC test report and (2) the decision in this regard need only be based on individual administrative problems or attitude toward acceptance of a report other than one issued by NBS.

Sensitive Research contacted NRC immediately after receipt of Dr. Page's letter to find out what the NRC position was towards the testing of equipment designed for *American* users. NRC indicated that this was entirely satisfactory, and gave a schedule of fees, a portion of which is shown in the Table. Sensitive Research is now having testing accomplished at NRC for many of its customers in the United States. However, as many customers are not familiar with the facilities or reputation of NRC, most requests are still for NBS Certification.

It is interesting to note that NRC faces the same problems as NBS. Both are anxious to devote more time to the development of procedures and instruments for the accomplishment of "tomorrow's measurements." However, such efforts are considerably retarded by the large volume of routine testing that is demanded of each facility.

The Test Report and the Certificate

There is one basic procedural difference between NRC and NBS. It is the policy of NBS to issue either a *Certificate* or a *Test Report*, whereas many other standards laboratories issue only Test Reports.

NBS Test Reports

Only a *Test Report* is issued for a particular instrument if NBS has not previously tested a statistical number of like instruments over a period of time. The Test Report is merely a recording of the figures obtained for a *particular instrument* submitted to them. NBS often adds probability factors to the actual results obtained in order to arrive at a final figure given in the report. NBS will always state, when applicable, that a lack of past history makes it impossible to assess the probable stability and reliability of the instrument. For this reason, in general, only Test Reports are issued for instruments of recent design, or for instruments whose long-term performance is as yet undetermined.

*Manufactured by Guildline Instruments, Ltd.—formerly Tinsley Instruments (Canada), Ltd.

A paper given before the Metrology Division, Los Angeles Section, American Society for Quality Control, August 26, 1960

NBS Certification

A *certification* is a Test Report on equipment on which NBS *has* compiled a past history over a period of years. The certification indicates that NBS thinks that the accuracy and repeatability guaranteed for the equipment will most likely be as the manufacturer states in his warranty. NBS will issue a Certificate usually only after it has retested an instrument many times with repeatable results, or has seen a great quantity of the same equipment. An example of the type of evaluation implied in a Certificate is given in the following excerpt from such a document as published by the Resistance and Reactance Section of the Electricity Division:

"1. *Accuracy*—At the time of test, the value of resistance given in this certificate was probably correct to the last figure given. The accuracy shown is based upon this Bureau's record of the stability of the resistor, or, for resistors submitted for the first time, upon experience with resistors of the same type. Ordinarily, resistors submitted for calibration for the first time will be certified to 0.005 percent and their values given to 0.001 percent. On subsequent tests high-quality resistors will be certified to 0.002 percent. It is expected that the resistance value will be reliable to the accuracy given for at least 1 year from the date of test.

2. *Stability*—An investigation of data on both sealed and unsealed standard resistors tested at this Bureau showed that the average annual change did not exceed 0.001 percent for nearly 90 percent of the standards. Rapid changes of several times that amount often occur immediately after the breaking of the seal of a container. Many unsealed resistors, especially those of 100 ohms and above, undergo seasonal changes which may amount to several hundredths percent even when the average yearly change is small."

NRC

NRC will issue a *Test Report* only. NRC policy is not to predict the future accuracy of any particular piece of equipment although, like NBS, they will point out accuracy and stability probability factors. They will, however, guarantee only that they obtained a certain set of figures—at a certain date—on one individual instrument.

There is an interesting point here because in effect NBS says the same thing as does NRC, regardless of whether it issues a Test Report or a Certificate. In other words, the NBS Certificate is only for an individual instrument. Since many users think NBS, by issuing a Certificate, is implying acceptance of all instruments manufactured of that type, there is room for misunderstanding, and there has been some speculation in the past as to the value of issuing two types of documents.

Brochures describing NRC testing facilities are available from NRC. In much the same manner as our own NBS, maximum cooperation has been given by NRC to industrial research and development firms. It cannot be over-emphasized that both organizations offer their services with enthusiasm, and extend their beneficial influence into industry far beyond what their limited operating funds would seem to permit.

Buy American Act

The Buy American Act has been revised recently. Certain Canadian electrical and electronic test equipments come under Federal Class Code 6625 and, in accordance with ASPR6-103 and 6-104, restrictions for procurement by the military have been removed. *The United States and Canada now have a reciprocal agreement whereby manufacturers in both countries can bid without prejudice for either United States or Canadian Government contracts.* This is as beneficial to United States manufacturers as to Canadian. Most people are unaware of the fact that if Canadian equipment is purchased with Government funds for an application involving National Defense, it can be brought into this country duty-free.

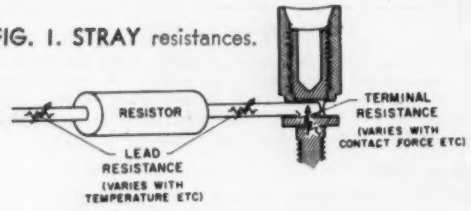
Number	Description of Test	Fee
	Electricity and Mechanics	
NOTE	The Section is prepared to make many electrical and mechanical measurements in addition to those quoted. The charges in such cases are based on the accuracy required and the time involved to make the measurement. Specific tests with fixed fees are listed below.	
Standard Cells		
18-2-1-1	Determination of e.m.f. of unsaturated standard cell at room temperature (21° ±1°C)	$ 10.00
18-2-1-2	Determination of e.m.f. of unsaturated standard cell at specified temperature in range 22° - 40°C	15.00
18-2-1-3	Each additional cell at same time and same temperature	5.00
18-2-1-4	Determination of e.m.f. of saturated standard cell at controlled fixed temperature (28°C) Other temperatures by arrangement.	20.00
Potentiometers		
18-2-2-1	Standardization of a potentiometer with a minimum subdivision of 100 microvolts	25.00
18-2-2-2	Standardization of a potentiometer with a minimum subdivision between 10-100 microvolts (less than 100 points checked)	80.00
18-2-2-3	As above, but when more than 100 points checked - Vernier type	100.00
18-2-2-4	Standardization of a potentiometer with a minimum subdivision of less than 10 microvolts	175.00
NOTE	The minimum subdivisions above apply to a multirange potentiometer when used on the X1-0 range. Multi-step voltage dividers (Kelvin-Varley type) will be assessed as a potentiometer with 1 volt impressed on the input.	
Volt Boxes		
18-2-3-1	Test for ratio on one range at voltages up to rated voltage, not to exceed 1500 volts	25.00
18-2-3-2	Test on each additional range	5.00
18-2-3-3	Test at an additional voltage on same range	3.00
18-2-3-4	Minimum fee for testing Volt Boxes	35.00
Resistance Measurements		
18-2-4-1	Determination of resistance of standard resistor (decimal multiples and sub-multiples of one ohm). Normally in oil at 25°C. Other temperatures by request	15.00
18-2-4-2	Determination of resistance of standard resistor (not a decimal multiple or sub-multiple of one ohm). Normally in oil at 25°C. Other temperatures by request	20.00
18-2-4-3	Determination of temperature coefficient of resistance in the range 15° - 30°C	40.00

FOUR- AND THREE-TERMINAL RESISTANCE MEASUREMENT

Four-terminal measurements increase accuracy of low-resistance measurements; 3-terminal for high-resistance measurements

JACK RILEY
Electro Scientific Industries

FIG. 1. STRAY resistances.



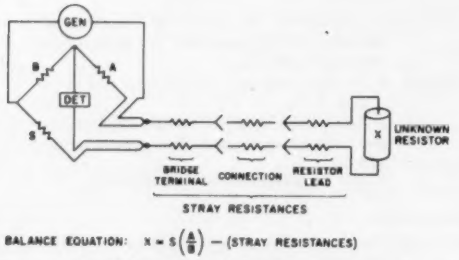


FIG. 2. WHEATSTONE bridge measures stray resistance plus unknown.

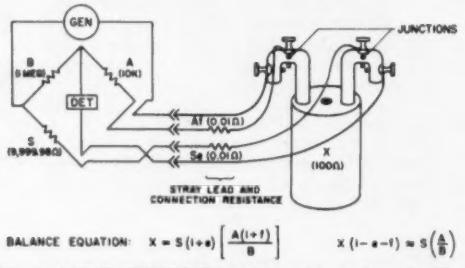


FIG. 3. WHEATSTONE bridge with reduced effect from stray resistance.

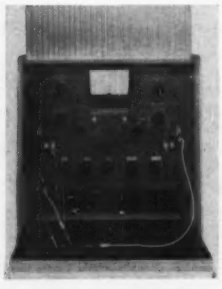


FIG. 4. FOUR-TERMINAL connection using the ESI Model 231 resistance bridge.

THE total resistance between two terminals includes stray lead and connection resistances (Fig. 1). When making precise resistance measurements these strays must be considered. Fig. 2 shows these stray resistances in the familiar Wheatstone bridge circuit. If the lead and contact resistances were fixed, we could measure them separately and subtract them from the bridge reading. Unfortunately, lead and terminal resistances usually have high temperature coefficients, so that small changes in room temperature cause large changes in their values. Also, connection resistance is influenced by dust, oxide and other contaminants, and by the force applied to the terminals. If the unknown resistance is near the stray resistance in value, large errors in bridge measurement result.

Four-Terminal Resistance Measurements for Low Resistances

In the two-terminal measurement shown in Fig. 2, the junction points are at the base of the bridge terminals. In Fig. 3 a four-terminal resistance connection is shown. By bringing four leads out from the bridge, the junction points have been moved onto the resistor being measured. The stray resistances are now in series with (1) the generator, (2) the detector and (3) the bridge arms A and S. The resistances in series with the generator and detector are not involved in the bridge measurement circuit and have no effect on the accuracy of the measurement. Resistance in series with bridge arms A and S, however, must now be included as a part of resistors A and S.

In Fig. 3 values have been assigned to the resistors. With the 4-terminal connection shown, the stray resistances will cause 2 ppm error (0.02 ohm in 10k ohms). However, with the bridge connected conventionally as in Fig. 2, a resistance of 100.02 ohms would be read from the bridge dials; this is a 200-ppm error in the resistance measurement. The lower the resistance being measured, the greater the advantage from the circuit of Fig. 3.

Commercial Wheatstone bridges often can be connected for this type of four-terminal measurement. Fig. 4 shows these connections for the ESI Model 231 Resistance Bridge.

Kelvin Clips

Spring clips with jaws insulated from each other (Fig. 5) permit rapid connections for precision four-terminal measurements. These clips have been named "Kelvin Klips" at ESI in honor of Lord Kelvin's contribution to four-terminal measurements.

Each clip has two leads; a wire is connected to each jaw of the clip. This provides a four-terminal connection to the resistance being measured. Only two clips are needed, one on each pair of leads. The four-terminal technique prevents any decrease in accuracy even though such clips may have a variable connection resistance of a few milliohms. This is true even when measuring resistances which are lower than the resistance of the clips.

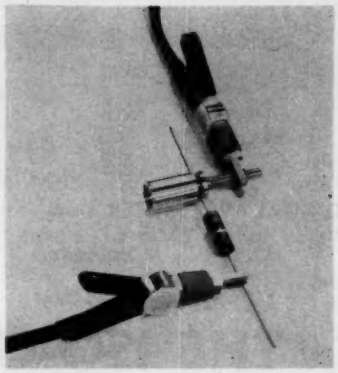


FIG. 5. "KELVIN KLIPS" for 4-terminal measurements.

Three-Terminal Resistance Measurements for High Resistance

When a resistor is mounted between two terminals on a terminal board made of insulating material, the leakage resistance of the board shunts the resistor. However, when the resistor is mounted between insulators on a metal terminal board (Fig. 6), the leakage is all to the metal board. A three-terminal measurement using the metal board as the third terminal can give the true value of the resistor with no measurable effect from the leakage.

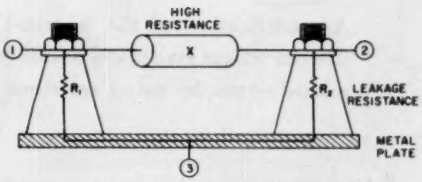


FIG. 6. HIGH RESISTANCE on a metal terminal board.

The third terminal (the case or mounting plate) is connected to a Wheatstone bridge as shown in Fig. 7. Note that leakage resistance R_2 is now across the detector, and causes no error. R_2 is usually larger than the meter resistance and merely reduces the latter's sensitivity slightly.

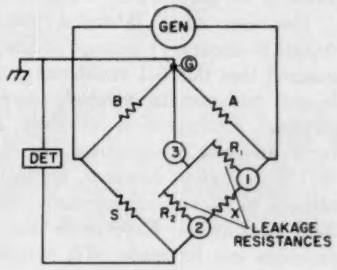


FIG. 7. THREE-TERMINAL connections to a Wheastone bridge.

Leakage resistance R_1 is across resistor A and does change its value slightly. With good insulation materials the resistance of R_1 can be made so much higher than that of A that this change also can be neglected. Thus, with the three-terminal connection, the resistor can be measured to high accuracy even though its resistance may be many thousands of megohms, and the leakage resistances of the same order of magnitude (as might be true on a humid day).

Fig. 8 shows the method of making three-terminal connections when using the Kelvin circuit. Here both the standard S and the unknown X can be connected as three-terminal resistors. When the resistances of X and S are high, the circuit on the right is a good approximation of the measurement condition. The leakage resistances R_2 and R_4 are across the detector and cause no error; R_1 and R_3 are across relatively low-resistance bridge arms so that normal leakage values do not give measurement errors.

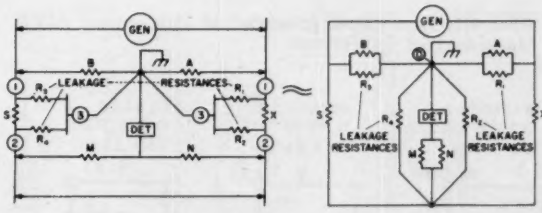


FIG. 8. THREE-TERMINAL connections to a Kelvin bridge.

The ESI Model 230-R Bridge (Fig. 9) measures to 12 gigohms (kilomegohms), and the ESI Model 240-R Bridge can be used for even higher values. These bridges are *guarded*—they are constructed so that insulator leakage paths never appear in parallel with the resistor being measured.

In the ESI Model 240-R Kelvin Ratio Bridge, all of the terminals are mounted on bushings which pass through the metal chassis. By connecting the chassis to Point D (of Fig. 8) all of the bridge leakage is across either the detector or a low-resistance bridge arm. Terminals connect the third terminal of three-terminal resistors to the chassis.

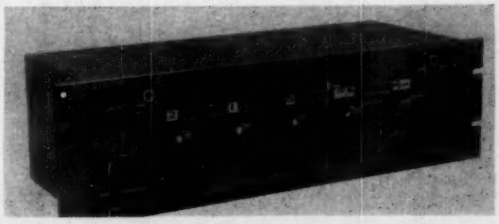


FIG. 9. GUARDED bridge for 3-terminal measurements.

DIGITAL VOLTMETER uses Iso-Ohmic Kelvin-Varley voltage dividers.

THE ISO-OHMIC VOLTAGE DIVIDER

A modification of the Kelvin-Varley voltage divider offers improved stability plus ease of manufacture by using resistors of one value.

PETER J. VAN BENSCHOTEN
Non-Linear Systems, Inc.

IN THE familiar Kelvin-Varley voltage divider, each decade is composed of resistors one fifth the value of the adjacent more-significant decade (Fig. 1).

The user of a laboratory-standard (0.001% to 0.0001% accuracy) voltage divider generally can rest assured that this 5:1 resistance ratio between decades is and will remain precisely correct because of the physical configuration of their resistors—they are large and not encapsulated. In digital voltmeters of 0.01% accuracy, however, encapsulated resistors are utilized to provide compactness and ruggedness under field conditions. Experience has shown that these resistors can be made with surprising precision and stability, and are adequate for a four-decade instrument in all respects. This, however, is not true for the five-decade instrument; a five-decade instrument will meet its accuracy specifications when it is new, but long-term drift of the small encapsulated resistors may degrade its performance a year later.

A solution to this problem consists of modifying the Kelvin-Varley divider so that all decade resistors have the same value. Fig. 2 shows the new divider, which has been appropriately named "Iso-Ohmic." The basic principle is the fact that 50K in parallel with 12.5K is 10K ohms. The principle is shown in Fig. 2.

The divider was developed to provide exceptional stability for five-digit voltmeters, and was first applied to the new five digit NLS Model V35 digital voltmeter which offers full five-digit (0.001%) resolution. Note that the least-significant decade is identical to all other decades; all decades are completely interchangeable. Tests for more than a year have proved

Abstracts from paper presented at 10th annual AIEE Machine Tool Conference.

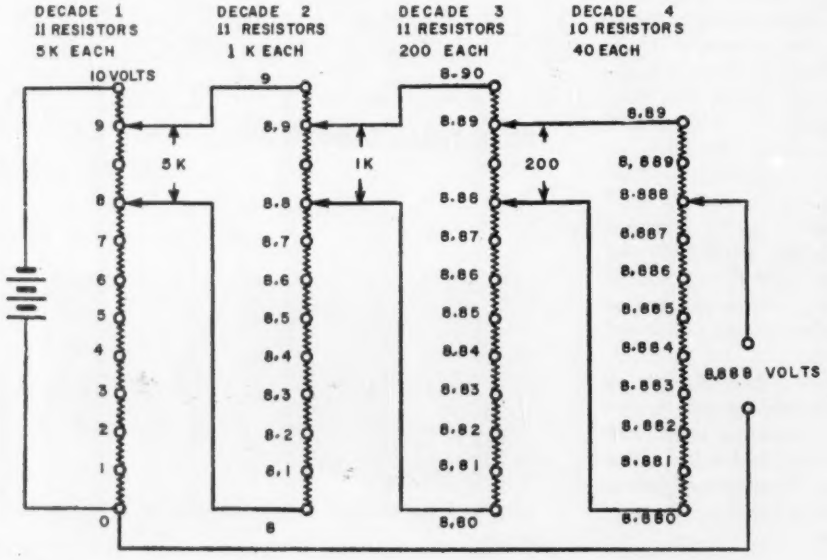


FIG. 1. CONVENTIONAL KELVIN-VARLEY voltage divider circuit. Each decade (except the last one) has eleven resistors, two of which are shunted by the next decade. As 2 resistors out of the (essentially) 10 resistor divider are in parallel with the succeeding divider, each resistor in one divider must have one fifth the value of the resistors in the succeeding divider.

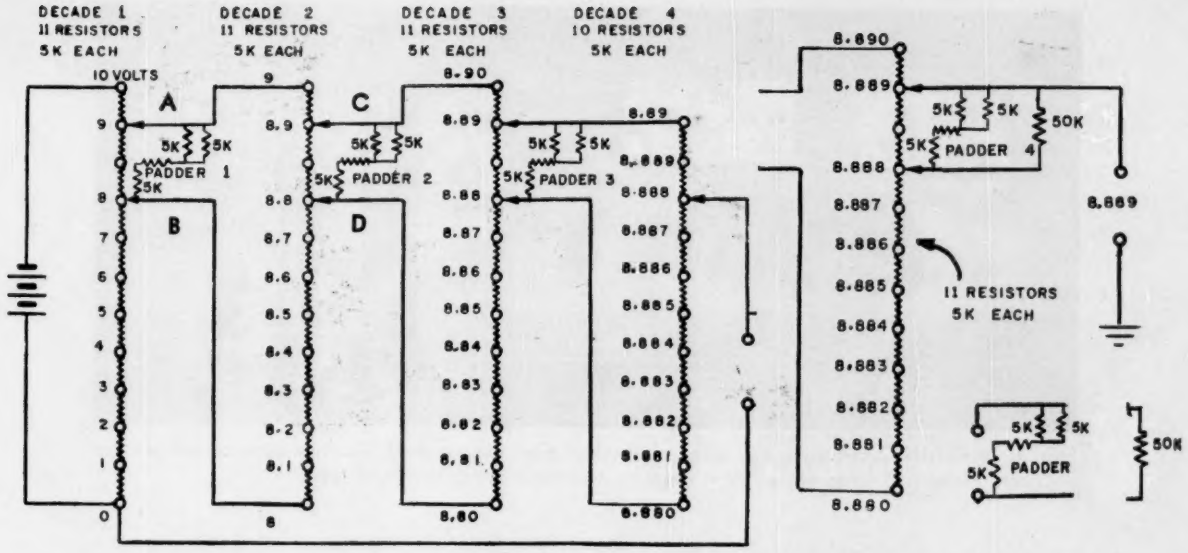


FIG. 2. ISO-OHMIC voltage divider uses resistors of the same value (5K) in every decade, and uses a padder so that the resistance between points A-B, C-D, etc. is exactly 5K ohms. Each padder (see lower right) comprises four 5K resistors, with an effective total resistance of 12.5K ohms. This 12.5K ohms, in parallel with 50K (the resistance of one chain), equals 10K ohms. This 10K is in parallel with two 5K resistors in the divider; hence the resultant resistance between points A and B is 5K, and decade 1 is a simple decade divider. Similarly the 50K total resistance of decade 3, in parallel with the 12.5K of padder 2, is 10K ohms. This results in 5K ohms between C and D. Final divider can be a conventional divider (as at left) or other iso-ohmic divider (as at right).

that the Iso-Ohmic Bridge is adequate for five-decade instruments. As all resistors are wound with the same number of turns of the same size wire, having the same temperature coefficient, the effects of any long-term drift tend to cancel, and the divider remains linear. If desired, the four 5K resistors used to "pad" each decade could be replaced by a single 12.5K-ohms resistor.

Beside providing a more stable voltage divider for the user, Iso-Ohmic construction not only reduces the number of types of precision resistors to be manufactured or purchased and stocked, but also permits use of resistors that are not uncomfortably high or low values of resistance on the extreme ends, where five or more decades are used.

The standard Wolff-Poggendorf * voltage divider (Fig. 3) can be made iso-ohmic by adding 5.555 . . . K padding resistors (resistors shown by dotted lines) and changing all the decade resistors to 5K. If the advantages of completely iso-ohmic construction is desired, each 5.5555 . . . K padder can be assembled from six 5K resistors.

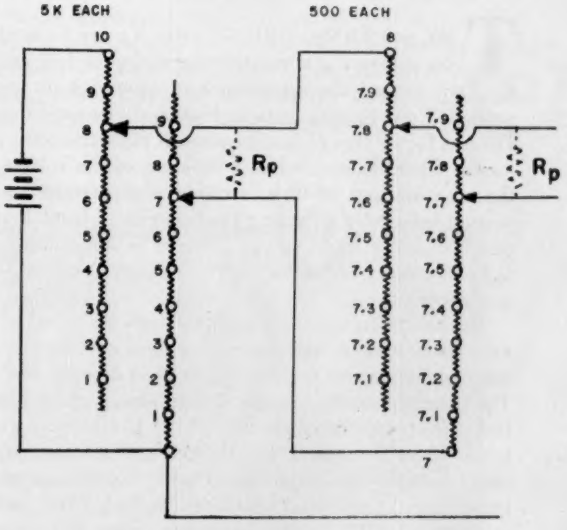


FIG. 3. WOLFF-POGGENDORF divider uses two divider chains per decade, and uses part of each chain in series with succeeding decade. As one resistance chain is increased, the other is decreased.

*The name "Poggendorf" is applied to most potentiometer circuits because Poggendorf originated the potentiometric measuring techniques. Sometimes, however, the name Poggendorf is omitted from various dividers. The major difference between the Wolff-Poggendorf divider and the Kelvin-Varley divider is that in the Kelvin-Varley divider each decade is shunted across resistors of the previous decade, and the switching circuit used results in fewer resistors (in the case of a four or five decade divider). In the Kelvin-Varley circuit, all resistors are in use at every position of the divider. In the Wolff-Poggendorf type divider, when a resistor is placed into the upper half of the divider, a resistor is taken out of the lower half, with the result that half of the resistors of the divider shown are generally unused.

It is possible to construct a four decade Wolff-Poggendorf circuit with as few resistors as a four-decade Kelvin-Varley circuit has. This is usually not done because the switching circuit required for such a divider is much more complex and is often uneconomical, even though fewer resistors are used.

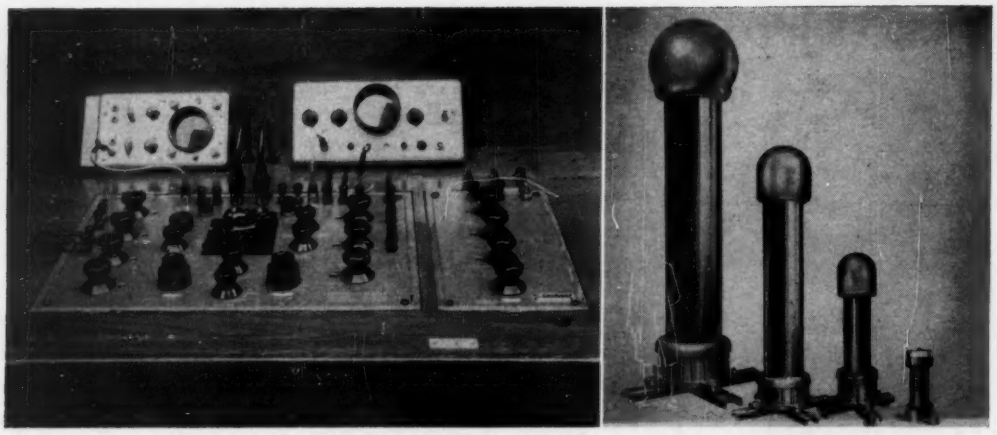


FIG. 1. **BUILT-IN** Schering bridge with accessories; also various-sized loss-free compressed-gas capacitors. Height of large capacitor is seen by comparison with sketch of man.

Schering Bridge

The Schering bridge permits the measurement of capacitors, including loss factor, at voltages up to and beyond a million volts.

PETER LETICA
Epic, Inc.

THE SCHERING BRIDGE (Fig. 1) can be used for measuring accurately the dielectric loss factor (tan δ) and the capacitance of grounded or ungrounded test objects, both at high and low potential. The loss factor (tan δ) is a measure of dielectric energy losses. When determined as a function of the voltage, the measurement of this variable also permits important inferences regarding the behavior of insulating material under high voltage. Thus it is important to test all components under high-voltage stress by tan δ measurements.

The bridge voltage used is limited only by the standard-capacitor used; the present standard capacitor for maximum voltage is presently 1400 kv (1.4 megavolts). The Schering bridge permits determination of the loss factor from approximately (2) (10^{-5}) to 1.111. An external capacitor (see Fig. 1) extends this measuring range further. The capacitance range depends on the capacitance of the standard capacitor. With a standard capacitor of 100 $\mu\mu$f the measuring range is from 3 $\mu\mu$f to 10μf. When using separate shunts, the measuring range can be extended beyond 1000 μf.

The bridge is suitable also for determining the dielectric constant of solid and liquid insulating materials. It is possible to measure the loss factor and the capacitance of dry capacitors and electrolytic capacitors of all types with low voltage. A special Schering bridge can be used with an oscillograph for determing the voltage of the beginning of the corona discharge.

Principle

The Schering bridge is used to measure the loss factor and the capacitance of the test specimen C_x (Fig. 2). It is especially suitable for tests carried out at high potential, but the same considerations can be applied to simpler low-voltage measurements. The high-voltage-proof, no-loss standard capacitor C_n and the test specimen C_x each form one arm of the bridge. Common point 2 is at high voltage. The two remaining arms of the bridge are formed by the variable resistance R_3 and the resistance R_4. Variable capacitor C_4 is in parallel with R_4. At balance, the setting of resistance R_3 is a measure of the *capacitance* of C_x, and the setting of the capacitor C_4 is a measure of the *loss factor* (tan δ). The instrument used for balancing the bridge can be a null indicator or

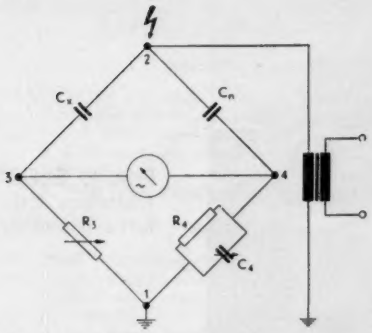


FIG. 2. SCHERING BRIDGE, basic diagram.

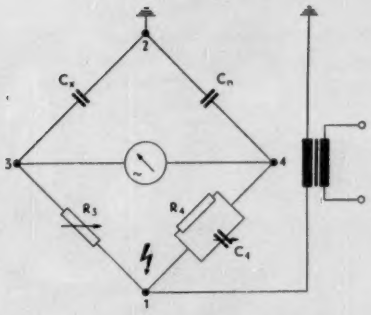


FIG. 3. SCHERING BRIDGE with the corner (point 2) of the bridge earthed. The bridge is mounted so that it is insulated from the ground, and is controlled by rods.

galvanometer. The null indicator should respond only to the basic frequency to obtain a satisfactory balance, even if the voltage contains higher harmonics.

After amplitude and phase have been balanced:

$$C_x = C_n(R_4/R_3)\,;\ \tan\delta = \omega R_4 C_4$$

Resistance R_4 is so selected that the value of C_4 is in decade relation to tan δ. Normally, this resistance is calculated for a measuring frequency of 50 cps and has the values $1000/\pi$ or $10000/\pi$. If required, it also can be designed for other measuring frequencies, such as 60 cps.

The secondary side of the high-voltage transformer and bridge point 1 are at ground potential. Resistances R_3 and R_4 and capacitor C_4 are so dimensioned that the corner points 3 and 4 of the bridge, and thus the measuring equipment, are at low voltage. If one capacitor coating of the test specimen is connected to the case (e.g., coiled cable), the latter must be insulated against ground. However, this insulation need only be sufficient for low voltage. If the test object is grounded by necessity (e.g., an installed cable) the Schering bridge can be used for carrying out the test in accordance with either of two methods:

The first method has the measuring equipment insulated with regard to high voltage and remotely controlled by rods, as in Fig. 3. Corner point 2 is now grounded. This method should always be used if the voltage supply is ground.

The second method for measuring grounded test objects renders the interfering stray capacitances ineffective by auxiliary equipment and pre-balancing (Fig. 4). Point 3 on the bridge is now grounded, but neither side of the voltage supply is grounded. When employing this method, insulated mounting of the Schering bridge is unnecessary. This method requires that the voltage supply be disconnected from ground.

The Schering bridge is chiefly used in the electrical and chemical industry to study the quality of insulation material between two conductors at different potentials. The quality of insulation material should be permanent, so that it will never vary because of voltage, temperature or the length of time in use. Examples of practical use of the Schering Bridge are measurements on: capacitors, cables, insulation equipment, power and other transformers, switches, generators, motors, synthetic materials and insulation oils.

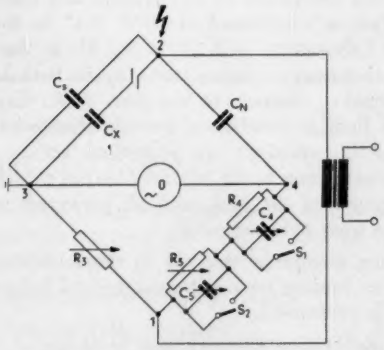


FIG. 4. MEASURING earthed test objects by means of auxiliary equipment.

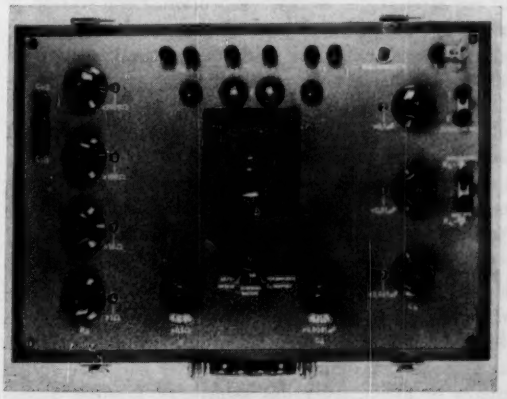


FIG. 5. SCHERING BRIDGE.

FIG. 1. ELECTRONIC Metrology Lab of Kearfott's Metrology Dept.

ELECTRONIC METROLOGY DEPARTMENT

Here are the facilities, procedures, equipment capabilities of the Electronic Metrology Section of an experienced metrology department.

J. FLYNN
Kearfott Div.
General Precision, Inc.

THE METROLOGY DEPARTMENT, part of Kearfott's Quality Control Branch, is responsible for the control of inspection tools and gages, electronic standards, calibration, certification, and preventive maintenance measures. Functioning within this department are the *Electronic Metrology Section* and the Mechanical Metrology Section. Each section is staffed by experienced and skilled engineering and technical personnel who work under the direction of the Chief Metrology Engineer.

The Electronic Metrology Section performs Master Reference surveillance, inspection, and calibration of test equipment for electrical characteristics as well as time, frequency, angular measurement, temperature, pressure, and vacuum. In addition, this section supervises the activities of the Electronic Metrology Lab.

All standards in the Metrology Department are regularly submitted for certification to the National Bureau of Standards, or to other primary level agencies which, in turn, submit them to the National Bureau. To provide maximum certainty that certified values remain in tolerance, cross references between standards are performed constantly.

Facilities and Procedures

Each laboratory encompasses an area of 1000 square feet in specially designed rooms isolated from the rest of the building. All measurements and calibrations are performed on special work tables under stringent environmental conditions of temperature and humidity: temperature is maintained at 68°F ±1° in the Mechanical Laboratory, and 72°F ±1.5° in the Electronic Laboratory; relative humidity in both laboratories remains constant at less than 50%. Carefully designed lighting conditions provide shadowless and glare-free illumination; an acoustical ceiling minimizes noise; access to the laboratories can be achieved only through an air lock, and all personnel are required to wear nylon smocks.

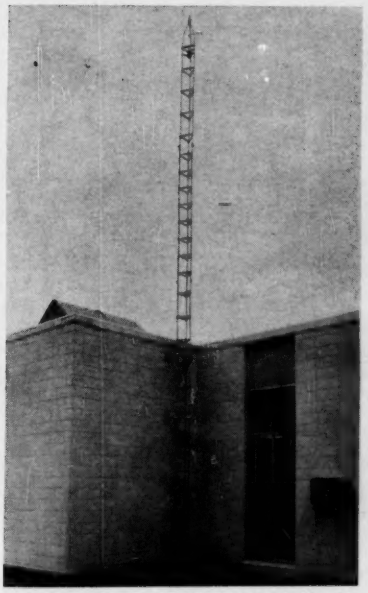
Working standards received in the laboratory are allowed to become temperature stabilized before calibration is performed.

Since calibration examinations in excess of 15,000 per year are performed by the laboratories, punched-card systems are used to assure an accurate record and an even distribution of work.

TABLE 1—ELECTRICAL EQUIPMENT CAPABILITIES

	RANGE	ACCURACY
*AC and DC VOLTAGE	0-1500V to 20 kcps	±0.05%
AC Voltage: Thach Voltmilliammeter		±0.2%
DC Voltage: 1. B.S. Voltmilliammeter		±0.05%
2. K-3 Potentiometer		±0.03%
3. Volt Box		±0.03%
4. Fluke Power Supply		±0.03%
AC and DC CURRENT	0-15 amp to 20 kcps	±0.05% DC ±0.1% AC
AC Current: Thach Voltmilliammeter		±0.2%
DC Current: 1. B.S. Voltmilliammeter		±0.05%
2. K-3 Potentiometer		±0.05%
3. Shunt Box		±0.05%
4. Fluke Power Supply		±0.05%
*RESISTANCE	0.0001 ohms to 100 megohms	±0.01%
Standard Resistors Referenced to N.B.S.	1 ohm 10 ohm 100 ohm 1000 ohm 10000 ohm	
*INDUCTANCE (0.1μh to 1 henry with an accuracy of ±0.2%) Type 667-A Inductance Bridge	100 μh to 10 henries	±0.1%
*CAPACITANCE	0.1 μμfd to 10 μfd	±0.1%
Type 1610-A capacitance measuring ass'y		±0.1%
Direct Read—0.1 μμfd to 1150 μμfd		
Substitution Method—0.1 μμfd to as high as available standards		
**FREQUENCY	to 1 Mcs	3 pts in 10^7
Electronic Counter 524D	10 cps to 10.1 Mc	±1 count ±5/10^8
**TIME		
WWV Receiver		1 part in 10^7
TEMPERATURE	−76°F to 395°F	±0.01°F
	395°F to 680°F	±0.01°F
	680°F to 1800°F	±1.0°F
Precision Laboratory Thermometer Set Leeds and Northrup Millivolt Indicator Thermocouple Checking Furnace Standard Thermocouple Assemblies Millivolt Potentiometer Type 86-86		
PRESSURE	0- 100 psi	±0.15%
	50-6500 psi	0.05%
Precision low pressure test gages Dead weight tester		
VACUUM	atmospheric to	
High vacuum pumping station	10^{-7} mm HG	
Master vacuum gages		

* Fixed standards of DC voltage, resistance, inductance, and capacitance are available in higher orders of accuracy.
** Specified according to WWV transmission from N.B.S.



Atop Kearfott's Plant #3 in Little Falls, N. J., this antenna enables the lab to pick up accurate frequency and time standard signals emanating from WWV, which broadcasts frequency and time signals used as standards throughout the world.

TABLE 2—EQUIPMENT AND SUPPLIERS

EQUIPMENT	SUPPLIER
1. Thach Voltmilliammeter	Sensitive Research
2. BS Voltmilliammeter	Sensitive Research
3. K-3 Potentiometer	Leeds and Northrup
4. Volt Box	Leeds and Northrup
5. Fluke Power Supply	John Fluke
6. Shunt Box	Leeds and Northrup
7. Type 667-A Inductance Bridge	General Radio
8. Type 1610-A Capacitance Meas. Ass'y	General Radio
9. Electronic Counter 524 D	Hewlett Packard
10. WWV Receiver	Beckman Berkeley
11. Precision Laboratory Thermometer Set	Fisher Scientific
12. Thermocouple Checking Furnace (modified by Kearfott)	Scientific Glass
13. Standard Thermocouple Assemblies	Leeds and Northrup
14. Millivolt Potentiometer Type 86-86	Leeds and Northrup
15. High Vacuum Pumping Station	Veeco
16. Master Vacuum Gages	Master McLeod Gage

Note: Mention of supplier does not constitute endorsement. All sources should be checked for latest developments.

COMING NEXT MONTH:

In February, the topic for special emphasis will be pressure measurement and control, and the following articles will appear:

1. Potentiometer Pressure Pickups
2. Bourdon-Tube Gauges
3. High-Pressure Measurement
4. Decimal to Binary Converter (Digital Series).
5. The Computer as a Component (Digital Series).
6. Thin-Film Memories (Memory Series, started in Dec., issue).
7. Analytical Techniques for Stream Control
8. The Six-Dial Thermofree Potentiometer (PMA Journal)
9. Process Control Systems
10. The Simulation Council Newsletter
11. Accelerometer Calibration
12. Survey of Calibration Consoles

Instrument Calibration

THE PAST DECADE has seen an ever-increasing need for accurate and rapid means of calibrating measuring instruments in the 3% to 0.1% class. Early techniques involved the use of a standard meter having an accuracy at least twice as good as the meter under test, and a power supply common to both meters. The standard and test meter were connected in parallel for voltmeter calibration, and in series for current calibrations. The major drawbacks to this arrangement were the wide variety of standard meters necessary for complete calibration coverage of all meters which might be encountered, and the possibility of damage to the standard meter due to misadjustment of the power supply. Often the standard meter would be used as a working reference meter in experimental circuits, thus adding to the danger of overload damage or burnout of the standard.

The United States Naval Research Laboratory, in the late 1940's, contracted with Radio Frequency Laboratories, Inc. to design a-c and d-c self-contained instrument calibration consoles having the maximum accuracy commensurate with operator and instrument safety.

Consoles of two general methods were developed and are presently in use—the *direct-comparison method* and the *regulated-power-supply method.*

In the direct-comparison method the standard quantities are determined by reading the meter, Brooks deflection potentiometer, or null-balance potentiometer used in the console as a standard. The regulated-power-supply console makes use of a standard a-c or d-c reference emf, servo amplifiers, and regulated power supplies which are controlled by means of the servo amplifier. The output emf or current is adjusted by means of several dials controlling ratio-transformer taps or resistive decades. The output quantity is determined by appropriate markings on the several range and control dials.

Accuracy

It is important to keep an accuracy relationship of at least 2:1 between the meters to be tested and the calibration system. If meters not exceeding an accuracy of 2% are to be calibrated, a console having an accuracy of 1% or better is required. A calibration console having a basic accuracy of 0.25% will handle all meters up to the 0.5% variety. The direct-comparison-type calibrator generally falls into the 1% to 0.1% class; regulated-power-supply types usually, but not always, can be classed in the 0.1% to 0.05% accuracy range.

Versatility

An instrument calibration console should be capable of *current measurements* ranging from a few microamperes to at least 10 amperes. It should be capable of voltage calibrations from a millivolt through one thousand volts or more. Every effort should be made to obtain a console which furnishes the maximum diversity.

Reliability

In selecting an instrument calibration console the most important factor—and the most difficult to determine—is reliability. An instrument having an extremely high accuracy rating is useless if that accuracy does not remain stable for an extended period of time.

The reliability of a console is determined by the quality of the indicating instruments used if the unit is of the direct-comparison type, or the stability of the reference sources if the console is the regulated-power-supply type. Repeatability of switch contact resistance is an important factor in either type of system.

Where resistors are used in the measuring circuits, their stability is determined by the type of resistance wire used, and their heat treating and aging. The quality of the ratio transformers used in the a-c type calibrators determines their reliability to a great extent. These are all intangible quantities which cannot be ascertained at the time the console is acquired. The purchaser must rely on the manufacturer's reputation for quality and integrity.

Consoles

JACK M. JANICKE
Radio Frequency Laboratories, Inc.

The best electrical or electronic components can fail. Hence it is advisable that the calibration console be checked periodically. Certain ranges should be spot checked every month or two, with a complete recalibration at least once a year. The check and recalibration should be made using basic electrical standards such as potentiometer, standard cell, volt and shunt boxes (in the case of the d-c instruments). For a-c certification an accurate a-c transfer standard generally is adequate.

Many manufacturers of calibration consoles will recertify the systems of their manufacture (or will supply technical data) if the owner wishes. Recertification must be accomplished using standards which can trace their accuracy to the National Bureau of Standards.

Safety

Safety precautions involve two primary functions—protection of operating personnel against dangerous shock, and protection of the test meter and standard instrument against damage due to overload. Much depends on the operator being aware that high voltages do exist, and remaining alert so that he does not come in contact with leads carrying such voltages. It is advisable to use a transparent hood which is electrically interlocked into the console for measurements of 300 volts and higher. The meter under test is placed under the hood and emf cannot be applied until the hood is fully closed.

In the direct-comparison console the standard meters are effectively protected by limiting the applied voltage or current to within 150% of full scale for any given range. The meter under test can be protected against high overloads (caused by switching) with interlocks which de-energize the power supply if ranges are changed with the instrument energized. The amplitude controls then must be returned to zero before calibration can be resumed.

Operation

An instrument calibration console can be operated in either one of two basic ways. The console can be brought to a definite voltage or current level and the test meter read for deviation from nominal value. Conversely, the test meter can be energized to the particular point at which calibration is desired and the applied quantity read from the standard instrument.

Economics

One must weigh the man-hours saved by use of a console against the initial cost. Instrument calibration systems are priced from about $2,000 to more than $20,000. The price of the instrument is generally determined by (1) its accuracy, (2) the number of functions it will perform. Some consoles can supply d-c quantities, some only a-c; others can supply both a-c and d-c voltage and current.

The cost of upkeep of a calibration console is negligible except for a periodic recalibration, an expenditure usually not exceeding $200.

Applications

The primary use for which calibration consoles are intended is, of course, the calibration of meters. This includes vacuum-tube voltmeters of both the a-c and d-c types, panel meters, moving iron a-c instruments, electrodynamometers, digital voltmeters, and high-accuracy moving-coil d-c meters.

A calibration console can be used readily for purposes other than meter calibration. It provides an excellent means for checking the pick-up and drop-out current in relay testing. It can be used as a power supply in tests of high-accuracy four-terminal shunts, where the resistance of the shunt is checked at full current and at 20% of rated current, using a Kelvin bridge as the calibration standard.

The console also can be used to determine the emf or current being produced by a precision power supply. In this operation the output of the power supply and the output of the console are bucked together through a galvanometer or null detector. When null balance is achieved, the output of the supply is exactly equal to the output of the calibration console.

Instrument calibration consoles are in use by many manufacturers in the electronic, electrical, aircraft and instrument industries, as well as by service and repair facilities, development laboratories, and many branches of the government. They are finding application wherever electrical instruments require accurate calibration.

Next month: A survey of the calibration consoles of Radio Frequency Laboratories, Weston, Sensitive Research, Julie Research, etc.

Selecting a Potentiometer

A. R. BECHTEL
Gray Instrument Co.

IN SELECTING a portable potentiometer the first consideration is the type of input signal to be measured. When measuring EMF from sources other than thermocouples, the resistance of the source is a major consideration. The sensitivity of a galvanometer usually is expressed in microamperes per division. The microvolt sensitivity of the whole system (galvanometer, instrument and external resistance) is, therefore, the voltage necessary to drive the required microamps through this total resistance.

The sensitivity of galvanometer depends on the ampere-turns of its coil. However, increasing the number of turns increases its resistance not only due to the extra length of wire but also because smaller wire must be used to get it in the same space. Nevertheless, it often is a big advantage to use a coil of greater microamp sensitivity, even though it has higher resistance.

Consider a measurement from a 1000-ohm source. Internal instrument resistance is 20 ohms. Let us consider a 10-, 300-, and 1000-ohm galvanometer.

A. With a 10-ohm galvanometer, having 0.3-microampere-per-division sensitivity, total resistance in circuit is 1030 ohms. $V = RI = 1030 \times 0.3 = 309$ microvolts necessary to produce a movement of 1 division of the galvanometer pointer.

B. With a 300-ohm galvanometer, having 0.08-microampere-per-division sensitivity, total resistance in the circuit is 1320 ohms. $V = 1320 \times 0.08 = 105.6$ microvolts to produce a 1-division pointer deflection. The latter has approximately three times the sensitivity of the former system.

C. With a 1000-ohm galvanometer, giving 0.04 microampere sensitivity, total resistance in circuit is 2020 ohms. $V = 2020 \times 0.04 = 80.80$ microvolts. This is about 4 times the sensitivity of the 10-ohm galvanometer, under these conditions. Note also that the sensitivity of the higher-resistance galvanometer is less affected by changes in the external circuit resistance.

Use with Thermocouples

The following table gives the ranges recommended for different types of couples by Roesser and Wensel of the National Bureau of Standards:

	Usual Temperature Ranges		Maximum	
Type	C°	F°	C°	F°
Platinum-Rhodium	0 to 1450	0 to 2650	1700	3100
Chromel-Alumel	−200 to 1200	−300 to 2200	1350	2540
Iron-Constantan	−200 to 750	−300 to 1400	1000	1800
Copper-Constantan	−200 to 300	−300 to 570	600	1100

If the range is above 1200°C (2200°F) it is best to use platinum-rhodium couples. This type, because its calibration curve is well established and more constant than base-metal types, is also used commercially as a basis for calibrating other couples. It has low output (mv per degree change) and requires a sensitive galvanometer.

Chromel-Alumel is the best base-metal couple for high ranges up to 1200°C and, if it is necessary to measure both high and low ranges, this couple can be used. However, its output per degree falls off considerably below 0°C, being only 0.01 mv per 1°C at −200°C. Its curve is also somewhat irregular.

Iron-Constantan has the advantage of giving the highest mv per degree. However, it also has the widest variations in its mv-temperature curve. Until a few years ago there were at least three generally used curves—two of the leading manufacturers and the NBS. The NBS has revised its figures and this is now generally accepted. The Iron-Constantan mv-temp curves fall off quite a bit below 0°C, being only 0.02 mv per degree C at −200°C. For close measurement with an Iron-Constantan couple a calibration curve should be obtained covering the range to be used.

Copper-Constantan is generally recommended for close measurement in its range. While its mv per degree is lower than that of Iron-Constantan, it is generally more reproducible, and its mv per degree does not decrease below zero proportionately as much as the others. For this reason it is nearly always used when the temperature to be measured is below zero.

Accuracy

The accuracy desired is also a prime factor in thermocouple temperature measurement. The potentiometer is basically more accurate than the couple. However, aside from the calibration accuracy, the sensitivity of the galvanometer can be the limiting factor. If it is desired to read to 1°C, both thermocouple output and instrument sensitivity must be adequate. Galvanometer sensitivity is affected by both the internal resistance of the instrument and the thermocouple resistance. As the couple resistance increases, sensitivity falls off. If the potentiometer is to be used with a high-resistance couple it is best to order a galvanometer of suitable sensitivity.

Temperature Compensation

Temperature-calibrated instruments usually have internal automatic cold-junction compensation. Millivolt-calibrated instruments have manual compensators. However, for measurements over short ranges and for highest accuracy, it is best to use an ice cold-junction. Instruments can be supplied with a switch for cutting out the internal cold-junction compensator when desired.

MV-Calibrated Potentiometers

Where measurements are to be made with different type couples at different ranges, a mv-calibrated potentiometer is advisable. This can have a manually adjusted cold-junction compensator which can be used when desired, or cut out when using an ice cold-junction.

These potentiometers can be made versatile by having high and low ranges, and by having a galvanometer sensitive enough for the low range (or means for connecting an external high-sensitive galvanometer). Due to the fact that it is calibrated in equal steps it may also have the range divided between a step-switch and the slidewire, giving a much higher resolution than that obtainable on the slidewire only. Such types can be calibrated generally to a higher accuracy over a greater range.

Type of Galvanometer

The *pointer type* usually has a sensitivity adequate for an instrument with the slidewire range of not less than 10 mv. With a 200-division scale, this results in 0.05 mv per division.

For example, a pointer galvanometer having a 3-microamp sensitivity, with a 10-ohm system and 20 additional ohms in internal and external circuit, would have 90 microvolts over-all sensitivity, or a little better than ½ division pointer movement for 0.05 mv at the couple.

The *light-beam* galvanometer has, in effect, a weightless pointer over a foot in length, and thus has far greater sensitivity, approaching 10 times the sensitivity of the pointer type.

Eliminating Vibration

DOLPH FRANKLIN

Vibration and shock can cause harmful inaccuracies of precision apparatus, such as balances, electron microscopes, colorimeters, spectroscopes, etc.

When Hoffman La Roche Inc. expanded their laboratories, the new location selected had considerable vibration caused by centrifuges and pumps. A special table for mounting microchemical balances was constructed of a reinforced concrete block mounted on springs (Fig. 1). The block acts as an inertia mass isolated by the springs to reduce the movement of the balance. Oscillograph recordings show that the system has a 93% isolation efficiency. Microchemical balances mounted on tables of this type have precisions ranging from 1.1 to 2.6 micrograms even on a floor above six 40″ basket-type centrifuges, which operate at 900 rpm. Vibration specialists recommended mountings for 200 pounds load per isolator, with approximately 1.2″ deflection and a natural frequency of 172 cycles per minute.

In an underground laboratory of Bausch and Lomb Optical Company, Rochester, New York, there is a ruling engine for making diffraction gratings (Fig. 2). The slightest temperature change may cause intolerable errors. Heat from a person's body may expand the grating machine by as much as 1/10,000,000″. If a person stood over it for a few minutes it may be thrown out of adjustment for hours.

The engine cuts grooves in a thin aluminum coating on glass with such precision that 180,000 grooves can be made in a 6″ length of glass. Therefore, the laboratory is built on solid rock with side walls 21″ thick; the floor is 13″ thick. Walls and ceiling are covered with sound-absorbing material. The grating engine is mounted on a three-ton block of concrete and the entire mass is supported on vibration-absorbing steel springs. To isolate it further, some of the engine's operating parts are floated in mercury.

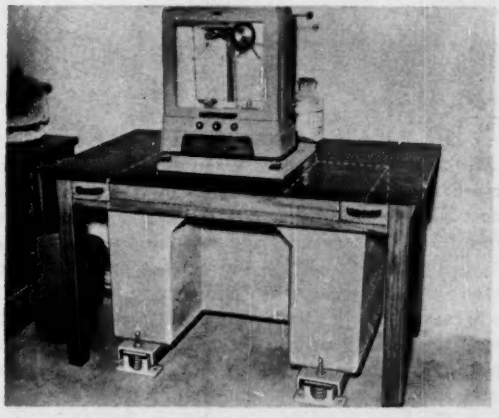


FIG. 1. MOUNTING for balance. (Photo courtesy the Korfund Co.)

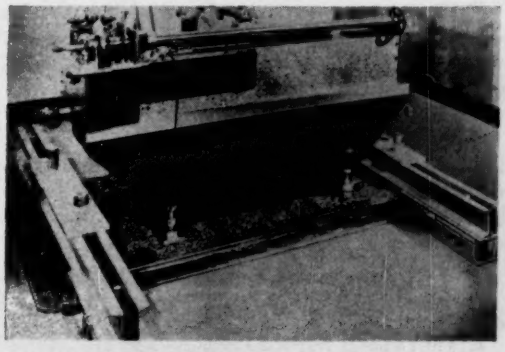
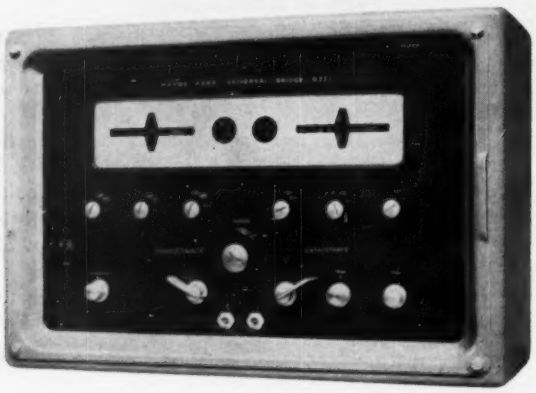


FIG. 2. GRATING ruling engine. (Photo courtesy the Korfund Co.)



The Transformer

The transformer ratio-arm bridge permits (1) independent measurement of resistance and reactance, (2) wide ranges of measurement and (3) high accuracies. The basic feature is use of highly accurate and permanent turns-ratios to make the comparison-type measurements.

THE VALUE of an impedance Z is, by definition, the ratio E/I, where E is the voltage across the impedance, and I the current flowing through it. The most direct way of measuring impedance is, therefore, to measure E and I and compute the ratio. However, it is more difficult and less accurate to make *absolute* measurements of voltage or current than it is to make a *comparison* measurement—that is, to compare the unknown with a standard impedance by means of a bridge circuit (Fig. 1). This is because ratios can be established more easily and accurately than absolute quantities.

The Conventional Bridge

Fig. 1 shows the conventional method of comparison based on the Wheatstone bridge. Z_u is the unknown impedance. Z_s is a variable standard impedance; Z_1 and Z_2 are known fixed standards.

At balance, the unknown impedance is:

$$Z_u = Z_s(Z_1/Z_2) \qquad (1)$$

The usual procedure is to balance the bridge by adjustment or selection of Z_s and the "ratio-arms" Z_1 and Z_2, which are arranged so that the ratio Z_1/Z_2 is adjustable in decade steps to provide a multiplying factor.

This method of measurement has a number of disadvantages:

1. The range is restricted because very low and very high standard impedances are difficult to manufacture with precision.

2. To ensure accuracy, a Wagner Earth arrangement is essential, requiring a double balance. This is inconvenient in practice and only two-terminal measurements are possible over any range. This is a severe restriction on impedances with reactance.

3. For accurate measurements, decade standards covering several decades of resistance and reactance must be used. At least 4 standards per decade are necessary, and the associated switches and wiring introduce spurious impedances that are difficult to handle. The standards are bulky and costly, and can only be made effectively pure over a small range.

4. With so many standards involved in the decade boxes and ratio-arms, calibration is difficult and often uncertain.

These disadvantages are reduced, and some eliminated, in the *transformer ratio-arm bridge*.

The Transformer Ratio-Arm Bridge

The basic circuit of the transformer bridge is shown in Fig. 2.

T_1 is a *voltage transformer* whose primary is connected to the source. The secondary winding is tapped to give sections having turns N_u and N_s.

T_2 is a *current transformer* whose primary is tapped to give n_u and n_s turns, and whose secondary winding is connected to the detector.

Assume that the transformers are ideal and Z_s is adjusted to give null indication in the detector. Under

Ratio-Arm Bridge

R. CALVERT
Wayne Kerr Laboratories

these conditions zero flux is produced in the current transformer; there is no voltage drop across its windings. Thus points A and B are at the same potential as point C, and the voltage across the unknown and standard are then E_u and E_s respectively.

Therefore $$I_u = E_u/Z_u$$
$$I_s = E_s/Z_s$$

For conditions of zero core-flux in the current transformer, the algebraic sum of the ampere-turns must be zero:

$$I_u n_u = I_s n_s$$

Substituting for I_u and I_s we have:

$$(E_u/Z_u)\, n_u = (E_s/Z_s)\ (n_s)$$
$$Z_u = (E_u/E_s)\, (n_u/n_s)\, (Z_s)$$

For an ideal transformer the voltage ratio (E_u/E_s) is equal to the turns ratio (N_u/N_s). Therefore:

$$Z_u = (N_u/N_s)\, (n_u/n_s)\, (Z_s)$$

This equation shows that, unlike the conventional bridge, two ratios (N_u/N_s and n_u/n_s) are available for manipulation. This permits a very high ratio product, permitting a wide range of measurement, simply by combination of taps on a transformer.

The Practical Bridge

One of the basic advantages of the transformer bridge is that it can measure reactance and resistance, independently.

In Fig. 3 the unknown and standard impedances

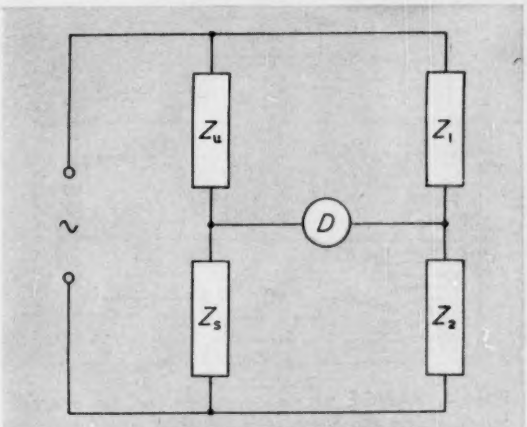


FIG. 1. WHEATSTONE BRIDGE.

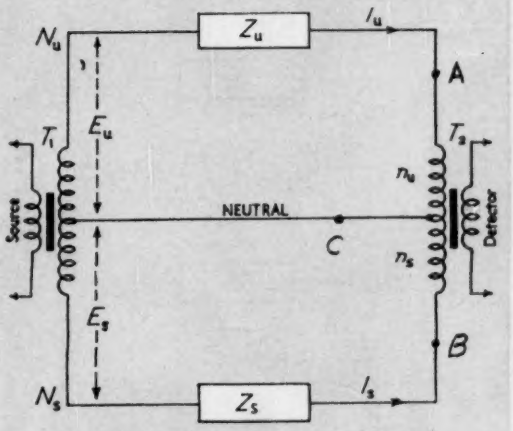


FIG. 2. TRANSFORMER BRIDGE.

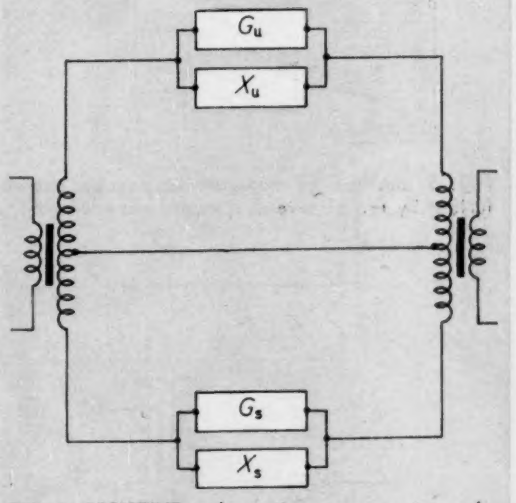


FIG. 3. RESISTIVE and reactive components can be measured independently because the in-phase (resistive) and quadrature (reactive) currents and voltages can be separately zeroed.

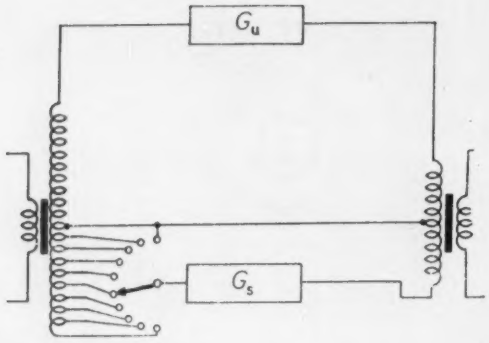


FIG. 4. RANGE of measurement can be altered by changing the turns ratio (N_s/N_u).

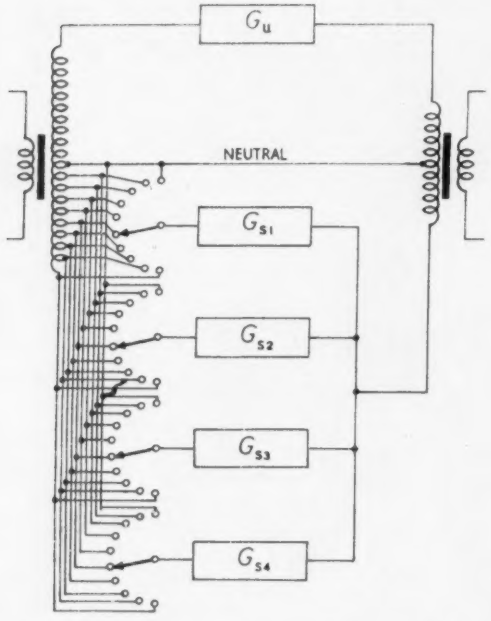


FIG. 5. RANGE of measurement can be altered further by use of several standard impedances.

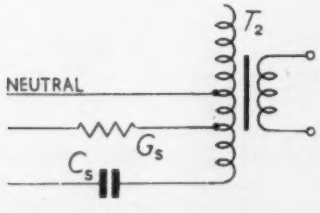


FIG. 6. STANDARDS multiplier has resistive and reactive standards on different taps.

have been divided into their resistive and reactive components. Since at balance the in-phase (resistive) and quadrature (reactive) currents and voltages must be separately zeroed, the conductance standard G_s and the reactance standard X_s can be connected to different tappings on the voltage transformer to balance out the currents caused by the unknown impedance. Hence the resistive and reactive components can be measured independently.

This can be put to advantage in many ways. The effect of impurities in the standards (for example, dielectric loss in capacitors) can be balanced out by the insertion of compensating components across the unknown side of the bridge. The leakage and capacitance across test jigs, etc., also can be removed in this manner.

The Decade Switches

Fig. 4 shows a bridge in which the voltage-transformer winding (N_s) has one hundred turns and is tapped at every ten turns. The taps are brought out to a switch and connected to one standard (G_s).

The equation for balance is:

$$G_u = G_s \ (N_s/N_u) \ (n_s/n_u)$$

Either the turns ratios or the standard impedance can be altered to change the range. Fig. 4 shows how a decade switch selects any of the taps to change the ratio N_s/N_u. Fig. 5 shows how the same 10 turns-ratios can be used with four standard impedances. Thus any of 4 resistances and 10 turn-ratios can be selected.

Each switch connects through a fixed standard to a common tap on the current transformer. The conductances are given the relative value 1, 10, 100 and 1,000. The effect is exactly the same as that obtained by having a transformer of fixed voltage and a four-dial decade box.

Continuing with taps to four more switches, each of which is connected through a fixed standard capacitor to the current transformer, the effect of adding a four-dial decade capacitor is produced.

Continuously Variable Controls

Only the step-by-step adjustment of the standards has been considered. It has been shown how the decade boxes for resistance (and capacitance) standards normally associated with accurate bridge measurements can be replaced by a few fixed standards and banks of switches fed from taps on the voltage transformer.

Decade switching is essential when accuracies of better than 1% are required. However, such switches alone can make balancing of the bridge a slow and laborious process, especially if the unknown is a complex impedance. The provision of a pair of continuously-variable direct-reading controls would make the bridge quick and easy to handle—but calibration difficulties would limit the accuracy of such an arrangement to 1 or 2%. Fortunately, it is possible with the transformer ratio bridge for continuously variable controls to be added without detracting from the accuracies of the decade standards.

The best practical compromise for accuracy and ease of operation is to use a single decade and a con-

tinuously variable control for accuracies of the order of 1%. A second decade need only be introduced when it is necessary to increase the accuracy to 0.1%, or when it is required to obtain very high discrimination at balance to measure small changes in impedance.

Standards Multipliers

To keep the number of standards to a minimum, the in-phase (resistive) and quadrature (capacitive) standards are chosen to cover approximately the same range of impedance at the operating frequency of the bridge.

Occasionally it is required to measure a complex impedance whose in-phase and quadrature components are of quite different orders. It is therefore convenient to be able to shift the effective impedance of one standard with respect to the other. As the voltage transformer is tapped to provide the decade adjustment of each standard, the current transformer must be tapped to shift the relative ranges of the standards. This is shown in Fig. 6. A pair of taps at, say, 10 turns and 100 turns will give a 10:1 shift.

This feature, however, must be used with caution because slight imperfections in the standard can cause gross errors in measurement of the minor component of the unknown.

Range Multipliers

It has been shown how the decade steps are obtained by suitably tapping the *standards winding* of the voltage transformer. The range of the bridge now can be extended above and below that of the standards by means of taps on the *unknown-side windings* of both the voltage and current transformers, as shown in Fig. 7.

For capacitance measurements, a convenient standard is 0-0.01 microfarad connected between the 100-turn and 10-turn windings respectively. Tapping the unknown windings at 1,000, 100, 10 and 1 turns gives the ranges shown in table 1.

TABLE 1. CAPACITANCE RANGES WITH FOUR TAPS ON UNKNOWN WINDINGS

Voltage Transformer Tap	Current Transformer Tap	Range
1000	1000	0-10 pF*
100	1000	0-100 pF
100	100	0-1000 pF
10	100	0-0.01 μF
10	10	0-0.1 μF
1	10	0-1.0 μF
1	1	0-10 μF

*1 picofarad (pF) = 1 micromicrofarad (μμF)

The standard multiplier described previously will extend the low-capacitance range of 0-1 pF. If the standard comprises two decade switches and a continuously variable control, the variable will cover the range 0-0.01 pF, and a 1% discrimination on this is 0.0001 pF. With attention to the screening of leads and connections, and if the standards are carefully trimmed, the bridge will measure from 0.0001 pF to 10 microfarads with an accuracy of ±0.1% ±0.0001 pF.

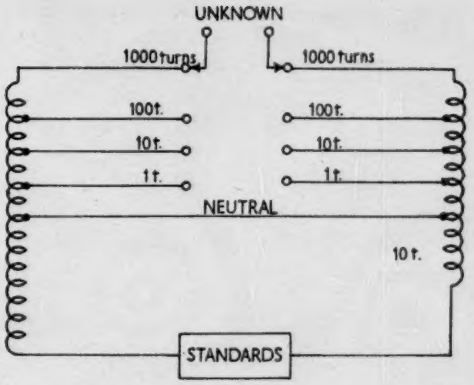


FIG. 7. WINDINGS on unknown side of bridge also can be tapped to further extend the range.

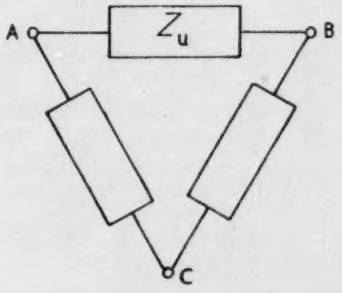


FIG. 8. ANY CIRCUIT can be resolved into a 3-terminal network like this.

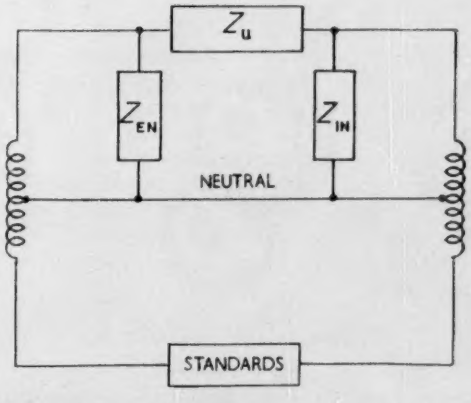


FIG. 9. MEASUREMENT of 3-terminal network with transformer ratio-arm bridge.

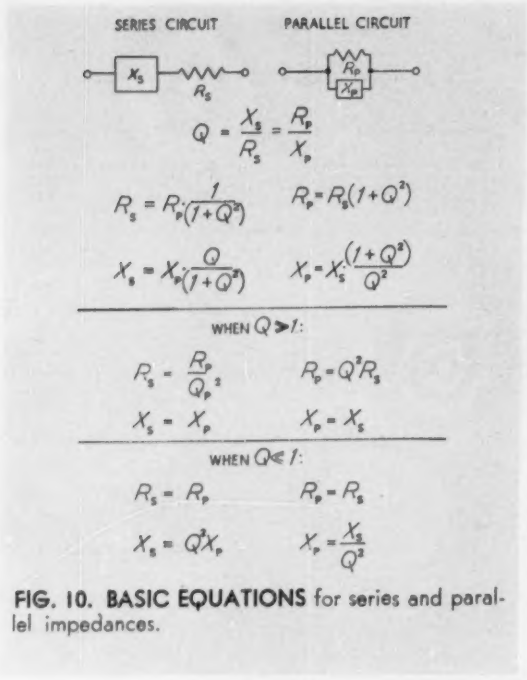


FIG. 10. BASIC EQUATIONS for series and parallel impedances.

3-Terminal Measurements

It is often convenient to be able to measure an impedance *in situ* (in place—without disconnecting any other components which may be associated with it). With certain test jigs it is often impossible to disconnect the effective shunt and stray capacitances to the base of the jig.

Generally speaking, any circuit can be resolved into a three-terminal network as in Fig. 8. The impedance to be measured is Z_u, but the effect of impedances Z_{AC} and Z_{BC} must be removed before a measurement of Z_u can be made. Fig. 9 shows the 3-terminal network applied to the transformer ratio-arm bridge.

Parallel to Series Conversion

As the bridge sums currents, it measures impedance as a parallel combination of the in-phase and quadrature components. For some purposes this is inconvenient and it is necessary to know the equivalent *series components*. The relevant equations are given in Fig. 10.

To avoid the awkward factor 2π appearing in all the calculations, the source frequency on certain bridges is fixed at 1592 c/s, so that $\omega = 10{,}000$. This not only simplifies the transformation of parallel circuits to series circuits, but makes it possible to read reactance in ohms directly from the capacitance scale. Also, by reversing the sense of the capacitance standard connections to the current transformer, it is possible to measure inductance; all readings are simplified if $\omega = 10{,}000$.

Extending the Lower Range

Although the bridge in its existing form covers an extremely wide range, the accuracy deteriorates rapidly when measuring impedances lower than about 10 ohms because the series resistance of the leads or switches becomes significant. For the measurement of very low impedances a different technique must be adopted.

So far, a *voltage* has been applied across the unknown and the resulting *current* compared with that in a standard. With impedances of the order of 10 ohms and below, it becomes increasingly difficult to apply a precise voltage, owing to the uncertainty of the voltage drop in the connections. It is now preferable to pass a *current* through the unknown and to measure the *voltage* drop across it. This cannot be done directly with the existing bridge arrangement, but it can be done by making the unknown the shunt element of a T-network (the series arms being fixed standard resistors) and measuring the transfer admittance.

Conclusion

The transformer ratio-arm bridge can make complicated measurements which would be difficult, if not impossible, with a conventional bridge arrangement. The advantages of the transformer bridge can be summarized as follows:

1. The measurement depends on the product of the current and voltage ratios for each fixed standard used. Both of these ratios are easily obtained with great accuracy, increasing the possible range of measurement to a figure well beyond the scope of impedance arms. Voltage and current ratios each of 1,000:1 are possible, giving an over-all ratio of 1,000,000:1.

2. As the ratios depend only on the number of turns on the transformer windings, they are permanent and calibration is unnecessary.

3. Only one standard is required for each decade. Furthermore, the transformer ratios can be used to set the standard in one decade against that in another, so that only two fixed standards of known accuracy are required—one resistive and one reactive.

4. The standards need not be pure. The effects of a resistive term associated with a reactance standard, and of a reactive term associated with a resistive standard, can be removed entirely at a given frequency.

5. The measurement of very small capacitances by conventional means is extremely difficult, due to the effect of stray capacitance and the difficulty in obtaining a standard of sufficiently low value. By means of the transformer bridge, it is possible to measure capacitors of the order of 0.0002 pF at the ends of leads having some thousand times this capacitance.

6. As the sign of a voltage or current can be reversed simply by reversing the connections to the relevant transformer winding, measurements can be made in all four quadrants of the complex plane. The bridge therefore can be used to measure transfer impedance as well as direct impedance.

7. The bridge will measure the impedance between any pair of terminals of a 3-terminal network. *In situ* measurements are possible on impedances remote from the bridge and on components wired into a circuit. The capacitance of long connecting leads and spurious impedances connected to the unknown terminals are completely counteracted by the appropriate use of the third terminal of the bridge.

New Type K-3 Potentiometer keeps Melpar's radar test gear "on the beam"

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This heavy workload of checking standards and instruments is easily handled by the K-3 because, as the head of the Quality Control Laboratory at Melpar says, its new design and convenience features permit "faster readings . . . and human errors are avoided because of the K-3's central reading window and decimal point indication of range. It is also much easier to standardize."

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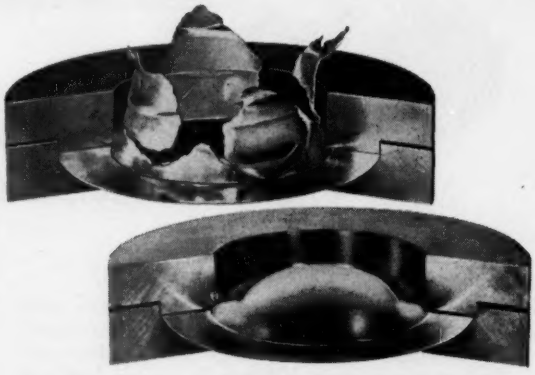
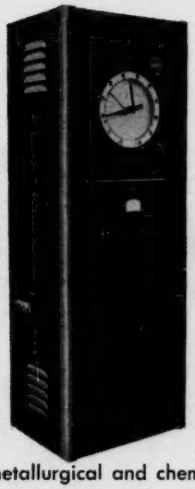
FOR ANALYZER CIRCLE 161
FOR FUSED QUARTZ CIRCLE 162



CORROSION-RESISTANT RUPTURE DISCS RELIEVE PRESSURE AUTOMATICALLY

In pressurized apparatus subject to corrosion, dependable precious metal rupture discs provide speediest, safest, most accurate relief from excess pressures. Made of gold, silver or platinum to resist corrosive effects of liquids and gases under conditions that would render many base metal materials useless. Complete line of rupture discs available—guaranteed to burst at ±5% of specified pressure. Economical to use—cost lowered by recovery of precious metal in spent disc. Write for literature.

BAKER PLATINUM DIVISION
113 ASTOR STREET • NEWARK, N. J.
FOR DEOXO INDICATOR CIRCLE 163
FOR RUPTURE DISCS CIRCLE 164



FOR DETECTION AND MEASUREMENT OF OXYGEN IMPURITIES IN OTHER GASES

In metallurgical and chemical processes requiring an oxygen-free atmosphere, the Minoxo Indicator provides a means of insuring that failure of purification or ingress of atmospheric oxygen through an unsuspected leak does not cause costly spoilage. The Minoxo Indicator . . . measures traces of molecular oxygen in other gases—from 0 to 10 parts per million, and from 0 to 100 PPM. High sensitivity and rapid speed of response enable it to be used for laboratory investigation and production quality control.

INDUSTRIAL EQUIPMENT DIVISION
GAS EQUIPMENT SECTION
113 ASTOR STREET • NEWARK, N. J.

HERMACH-ENGELHARD MULTI-RANGE TRANSFER VOLT-AMMETERS FOR UNMATCHED ACCURACY

Meets exacting calibration requirements for accuracy without use of correction factors over wide range of currents and voltages. Functional design employs null principle . . . provides simple operation. Hermach-Engelhard Transfer Volt-Ammeter achieves 0.05% accuracy through frequency range d-c to 50,000 cps, eliminating complete battery of measuring devices otherwise needed. • Several models available for efficient adaptability to various conditions. Write for details.

INDUSTRIAL EQUIPMENT DIVISION
INSTRUMENTS AND SYSTEMS SECTION
850 PASSAIC AVENUE • E. NEWARK, N. J.

PRECIOUS METAL CONTACTS FOR HIGH-RELIABILITY

Precious metal contacts in pure or alloyed forms of silver, platinum, palladium and gold provide unmatched resistance to atmospheric corrosion, deformation, arc erosion, binding and metal transfer. Baker high-reliability precious metal contacts are supplied as wire, rod, sheet and in a complete line of fabricated forms. Facilities are also available for manufacture to your specifications.

BAKER CONTACT DIVISION
207 GRANT AVE. • NEWARK, HARRISON P.O., N. J.

FOR MINOXO INDICATOR CIRCLE 199
FOR PRECIOUS METAL CIRCLE 200

ENGELHARD
INDUSTRIES, INC.
EXECUTIVE OFFICES:
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SALES OFFICES: CHICAGO • DALLAS • DETROIT • HOUSTON • LOS ANGELES • NEW YORK • ORLANDO • PROVIDENCE • SAN FRANCISCO • WASHINGTON, D. C.

Please send literature as indicated below, addressed to my attention:

- ☐ Minoxo Indicator
- ☐ Precious Metal Contacts
- ☐ Super-Sensitive Deoxo Indicator
- ☐ Rupture Discs
- ☐ Portable Atmosphere Analyzer
- ☐ Fused Quartz
- ☐ Hermach-Engelhard Volt-Ammeters

NAME.....

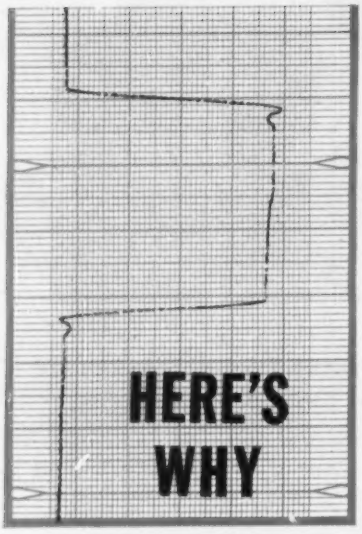
TITLE.....

FIRM.....

STREET.....

CITY.....ZONE.....STATE.....

FOR VOLT-AMMETERS CIRCLE 201



AO TRACEMASTER'S CARBON TRANSFER METHOD PRODUCES BETTER RESULTS!

The AO Tracemaster 8 channel recorder uses a direct-carbon-transfer writing method...clearly the best of all methods. The trace above, reproduced from a Tracemaster record, shows why!

Chart speed was 500 mm/sec. (Twice as fast as any other recorder). The trace is a gate pulse out of an Analab oscilloscope. Gate rise time is approximately 2.0 micro seconds. An amazing performance! Note the fine quality of the trace... the consistency of line through the entire band pass.

The direct carbon transfer technique makes this possible... mylar-backed carbon positioned between the stylus and the chart paper acts as an excellent lubricant. Stylus tip radius is smaller to produce a finer trace...yet there's no danger of "plowing". And it permits use of stylus pressure *5 to 7 times higher than with any other recorder* (velocity feedback signal out of the pen-motor applied to the linear driver amplifier makes the system much less susceptible to the effects of stylus pressure). This renders the system immune to ordinary shock and vibration stress... there's no ink splatter... little or no skip... no paper-tear.

Learn, in detail, all the advantages of the AO Tracemaster and its direct carbon transfer recording method. Send for complete literature. A request on your company letterhead will bring you an actual sample of an AO Tracemaster record.

American Optical Company

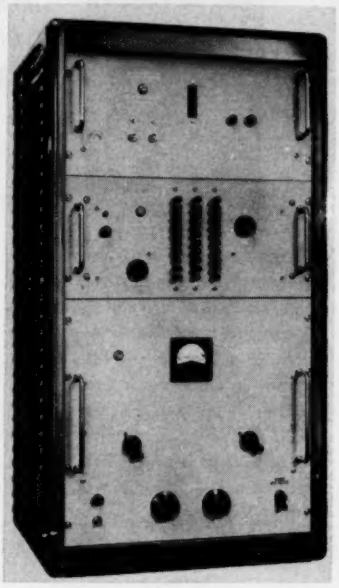
Instrument Division • Buffalo 15, New York

CIRCLE 64 ON READER-SERVICE CARD

ICS NEW INSTRUMENTS

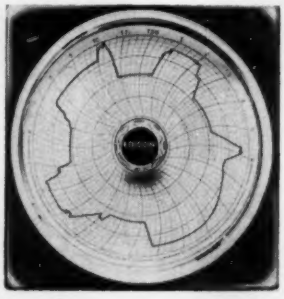
50-WATT AF SOURCE FEATURES 0.01% AMPLITUDE STABILITY FOR COMPARISON CALIBRATION WORK

New Model LDS-1500 variable-frequency power source is designed for use in Standards Laboratories and provides short-term amplitude stability of better than 0.01%. Instrument can supply adequate power for calibration, by the comparison method, of all a-c voltmeters and ammeters normally used for laboratory measurements. Short-term amplitude stability is achieved by a new oscillator circuit development. 40 watts of power are available over the frequency range from 20 cps to 20 kc with less than 0.25% total harmonic distortion, typically 0.1% at 50 watts over most of this frequency range. The following maximum rms voltages are selected by an output range switch: 3, 10, 30, 50, 100, 300, 750, 1,000 and 1,500 volts. Output power is nominal 50 watts over most of the frequency range into matched load impedance. Less than 0.005% amplitude change results for a ±10% variation in line voltage within the operating range.—*Krohn-Hite Corp., 580 Massachusetts Ave., Cambridge 39, Mass.*



CIRCLE 187 ON READER-SERVICE CARD

INKLESS RECORDER

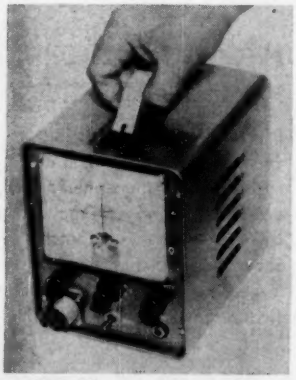


New 3¾" x 3¾" x 3" deep, circular chart Omnicorder records variables convertible to electrical signal, uses stylus to print graph on 3"-dia pressure-sensitive paper. Chart speeds available from one hour to 30 days/revolution. Available with four basic meter movements—D'Arsonval, crossed coil, moving iron and ferrodynamic. Stylus operates from back of chart. Available in explosion-proof case.—*Thomas A. Edison Industries, McGraw-Edison Co., West Orange, N. J.*

CIRCLE 188 ON READER-SERVICE CARD

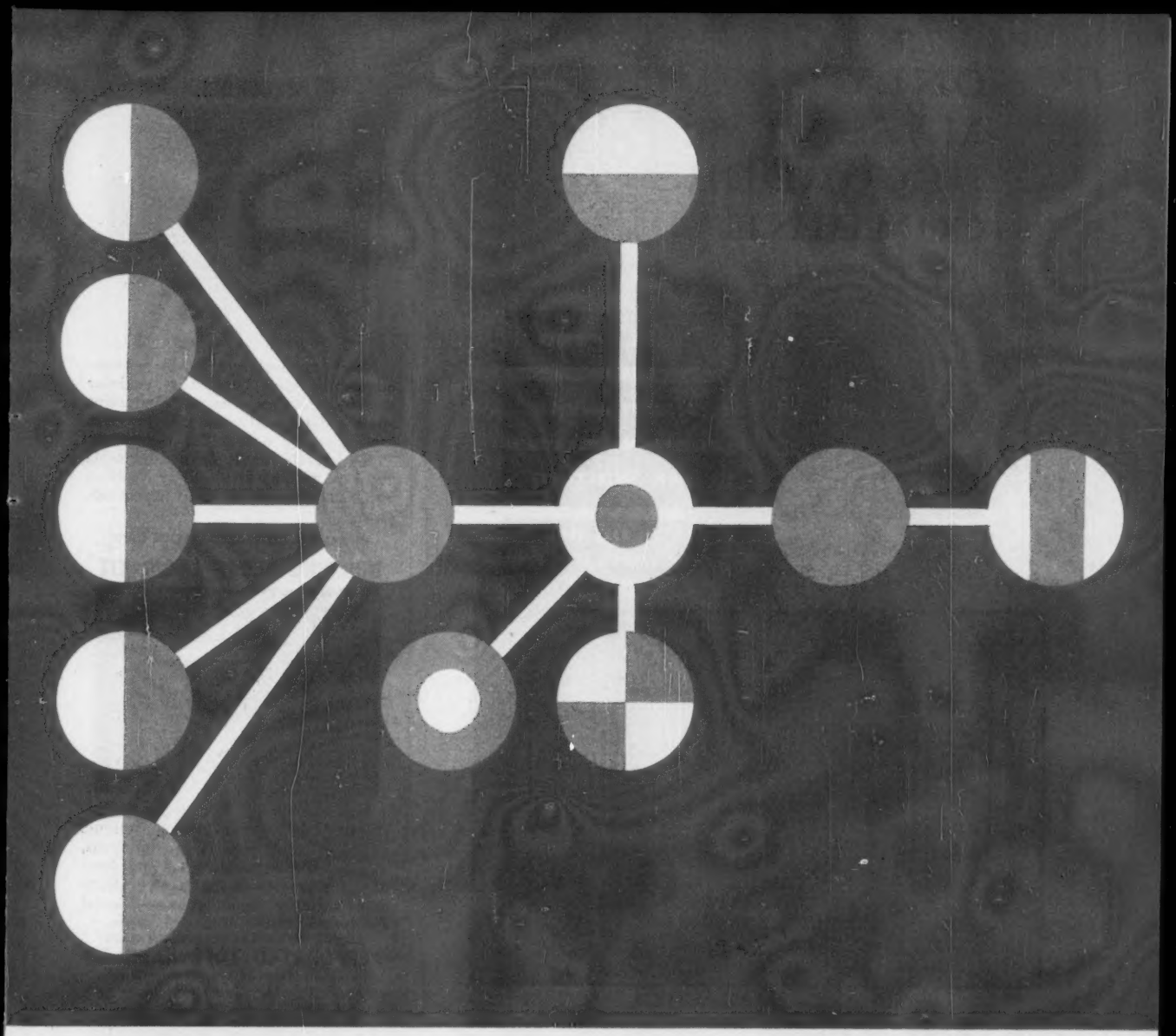
STRAIN GAGE CONDITIONER

New single channel portable "Strain Gage Transducer Conditioner and Power Supply" Model 110T accepts any resistance transducer and records on any galvanometer, millivolt recorder, or oscilloscope directly or through amplifiers. Can be used for calibrating transducers prior to installation and with 4, 5, 6, 7, or 8 wire input cabling systems, thus cancelling out cable losses.—*B & F Instruments, Inc., 3644 N. Lawrence St., Phila. 40, Pa.*



CIRCLE 189 ON READER-SERVICE CARD

CIRCLE 65 ON READER-SERVICE CARD →



When you specify process controls...

BUYING A LOOP OR A NOOSE?

Why "strangle" process technology? Hagan solid-state, electronic controls are designed to meet rigid specifications of high reliability, simplicity, and repeatability . . . yet, they're flexible and adaptive enough to meet changing process needs.

The core of Hagan's PowrMag electronic control loop is the controller. A high gain operational magnetic amplifier within the controller produces all control actions . . . proportional band, reset, rate . . . multiplication, addition and subtraction . . . through interchangeable resistive and capacitive components.

The Hagan electronic control system expands from this controller to other components that include all the hardware necessary for a simple or sophisticated control loop. From temperature, pressure and flow measuring devices to final control elements and data acquisition, each component has been engineered to meet high standards of reliability and accuracy.

For information on Hagan PowrMag electronic process controls, write HAGAN CHEMICALS & CONTROLS, INC., Hagan Center, Pittsburgh 30, Pennsylvania, or telephone WAlnut 2-3737.

SENSING ELEMENTS

TRANSDUCERS

CONTROLLER

REMOTE CONTROL STATION

RECORDER

DATA PROCESSING

FINAL CONTROL

HAGAN

ONLY MASSA RECORDERS COMBINE ALL

4

HIGH-SPEED

RECTILINEAR

INK WRITING

PLUG-IN PREAMPLIFIERS

MODEL
BSA-450
4 CHANNEL
40 MM

All of the exclusive features incorporated in previous Massa Recorders, including the *New Controlled Linearity Oscillographs,* are incorporated in the NEW 4 CHANNEL RECORDING SYSTEM. The all new front design greatly simplifies chart paper loading and permits full instant view of pen action and recorded signals on 7 x 10 writing table. Improved tracking, instant loading, accurate performance, are some of the novel features included in the new design.
Other features: 40 mm (full scale) Oscillographs, DC to 120 cps • Ink or electric rectilinear writing • 18 chart speeds, from 0.5 cm/hr to 200mm/sec • Event Marker • Automatic warning light for low chart indicator.

The new 4 channel recorder is now available in complete recording systems including individual transistorized driver amplifiers and power supplies for each channel, and a choice of interchangeable plug-in preamplifiers including DC, AC, Carrier and Chopper.

MASSA
A DIVISION OF
COHU
ELECTRONICS, INC.
276 LINCOLN STREET
HINGHAM, MASSACHUSETTS

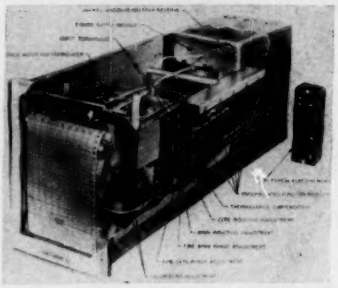
OTHER MASSA PRODUCTS

COMPLETE LINE OF
MULTICHANNEL AND PORTABLE RECORDING SYSTEMS

ACCELEROMETERS
HYDROPHONES
MICROPHONES
AMPLIFIERS
SONAR TRANSDUCERS

CIRCLE 66 ON READER-SERVICE CARD

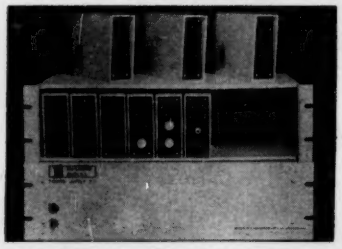
RECORDER



New transistorized 3-pen potentiometer-recorder features modular circuits, battery reserve, inductive span and zero adjustments; provides low noise d-c output for computers. Potentiometer input span adjustable from 0-5 to 0-50 mv.—*deVar Systems Inc., 494 Glenbrook Rd., Glenbrook, Conn.*

CIRCLE 190 ON READER-SERVICE CARD

BUILDING BLOCK LOGIC KIT



New Building Block Logic Kit includes basic selection of logic circuit packages and accessory equipment, can be used to design, test and demonstrate variety of logical operations and training applications.—*Digital Equipment Corp., Maynard, Mass.*

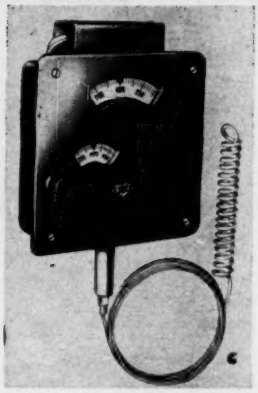
CIRCLE 191 ON READER-SERVICE CARD

PERFORATED TAPE HANDLER

New bi-directional perforated paper tape handler, DYKOR Model 4566 "Servo-Spool", permits reading of perforated tape at speeds up to 400 characters per second, and rapid rewind at 1,000 characters per second. Eight-inch reels hold 500' of tape, are controlled by 3-zone contactor system which performs as full servo system, and accepts 5 to 8-level tapes interchangeably.—*Digitronics Corp., Albertson Ave., Albertson, L. I., New York.*

CIRCLE 192 ON READER-SERVICE CARD

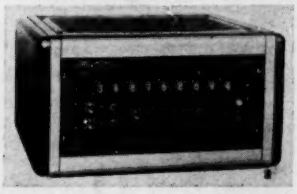
INDICATING CONTROL



New E32NA dual-switch, Indicating Temperature Control covers −150° to +650°F for ovens, baths, environmental test chambers, molding machines, etc. Features a calibrating mechanism allowing easy replacement of thermal assembly and contains two switches permitting switch action above or below the index set point and control of up to four independent circuits.—*United Electric-Controls Co., 85 School St., Watertown 72, Mass.*

CIRCLE 193 ON READER-SERVICE CARD

100-Mc COUNTER



New 100-Mc transistorized Model 1050 Gated Counter counts random events with better than 10-nanosecond double pulse resolution, functions as time interval meter to measure duration to within 10 nanoseconds, and measures any frequency up to 100 Mc/sec. It uses five binaries instead of four and offers nine digits of storage with in-line (Nixie) display. —*Eldorado Electronics, 2821 Tenth St., Berkeley 10, Calif.*

CIRCLE 194 ON READER-SERVICE CARD

MINIATURE TRIM POT

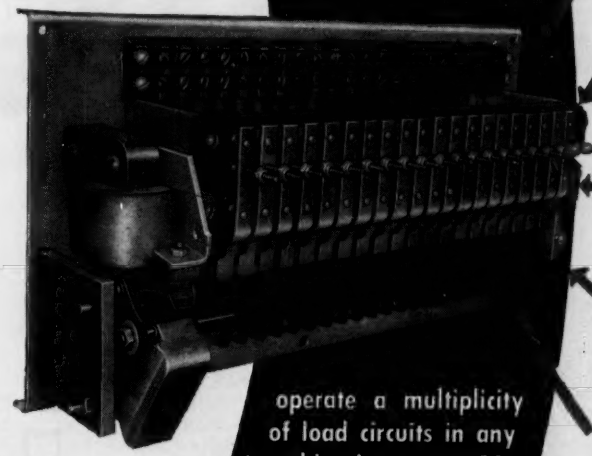
New ½-oz sealed metal-to-metal Type B329 potentiometer provides hermetic gas barrier while permitting external trim adjustments. Features resistance range up to 8400 ohms, ⅓-w rating at 85°C continuous operation, and operating ambient temperature range from −50° to +100°C.—*Liquidometer Corp., Long Island City 1, N. Y.*

CIRCLE 195 ON READER-SERVICE CARD

Step Sequencing

the new **Eagle Step Switch**

use any type of time or sensing device to advance the *Eagle Step Switch*



operate a multiplicity of load circuits in any combination up to 19 circuits

This new Eagle Step Switch also provides:

1. SEQUENCING INTERLOCK when used with multiple indexing circuits.
2. 10 AMP SWITCH CONTACTS control load switches direct — no need for load relays.
3. MECHANICAL CIRCUIT INTERLOCK by cam action — eliminates interlocking relays.
4. 115 VOLT COIL operates direct on AC with heavy duty ratchet mechanism — insures long life.

Write us regarding your count problem, or see your local phone directory or Thomas Register under the heading, "Timers, Electric" for your nearest Eagle Signal representative.

OTHER POPULAR HIGH QUALITY EAGLE TIME-COUNT CONTROLS

BLISS EAGLE SIGNAL COMPANY • Moline, Illinois
A DIVISION OF THE GAMEWELL COMPANY, AN E. W. BLISS COMPANY SUBSIDIARY

MANUFACTURERS OF A COMPLETE LINE OF INDUSTRIAL TIME-COUNT CONTROLS

CIRCLE 67 ON READER-SERVICE CARD

no
problems
with...

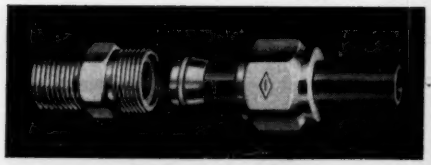
CLOSE BENDS

CLOSE BENDS

With Hi-Seal® fittings you can make tube bends close to the fitting—in fact, right next to it. Here Hi-Seal is in a class by itself.

Hi-Seal's simplified design with flareless butt joint makes this possible. The advantages? More compact lay-outs. Save on tubing. Shorten installation time by as much as 50%. Gain utmost reliability. SAVE MONEY. To get these advantages, insist on Hi-Seal.

For complete information, write for Bulletin 3108.



BUTT JOINT HI-SEAL

IMPERIAL EASTMAN

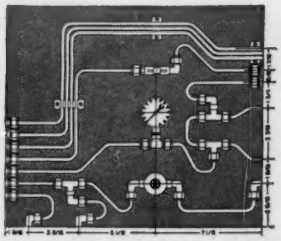
Imperial-Eastman Corporation General Offices: 6300 West Howard Street, Chicago 48, Illinois

In Canada: Imperial-Eastman Corporation (Canada) Ltd., Toronto

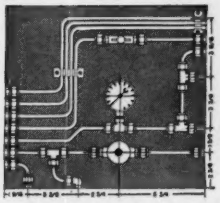
CIRCLE 159 ON READER-SERVICE CARD

Close Bends with Hi-Seal Save Time, Space, Tubing

Look at what you can do when you use Hi-Seal fittings:



This typical layout has "old-fashioned" tube fittings. Layout area, 257 sq. in.; 12.7 ft. of tubing; *installation time 2 hr., 34 min.*



Same layout with Hi-Seal tube fittings. Layout area reduced 32% to 175 sq. in.; tubing reduced 40% to 7.7 ft.; *installation time reduced nearly 50% to 1 hr., 20 min.!*

All this is possible because of Hi-Seal's exclusive flareless, butt joint design. This means that tube bends may be made right next to the fittings. Even direct tube connections may be made without any extra loops to allow for tube entry into the fitting.

One Fitting for the Entire System

However varied your requirements may be, Hi-Seal meets them. Available in all styles, sizes and combinations, plus a variety of metals: steel, stainless steel, brass, aluminum, titanium, Monel, etc.

Now Imperial-Eastman meets all your requirements for hydraulic-pneumatic-flow system components: tube fittings, valves, couplings, flexible and rigid hydraulic and pneumatic hose, thermoplastic tubing, tubing tools.

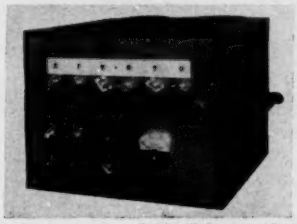
FITTINGS

IMPERIAL - EASTMAN

CIRCLE 159 ON READER-SERVICE CARD

AC REFERENCE

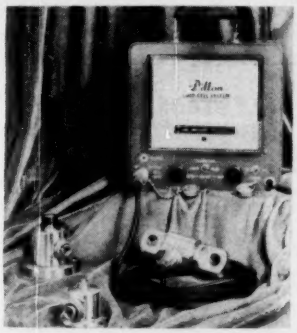
New Model 146A transistorized AC Reference Standard is designed to rigid mil specs for work in standards



labs, incoming and final inspection of ac measurement instruments and components such as gyros and resolvers. Range, 0-511.110v ac rms; accuracy, 0.035% of reading, ±1 mv, 25°C ±10° with moderate loading.—*Rotek Instrument Corp., 733 Concord Ave., Cambridge, Mass.*

CIRCLE 196 ON READER-SERVICE CARD

REMOTE READING LOAD CELL



New remote indicating load cell system permits instantaneous, direct readings of forces, in pounds, over 1000′ from actual cell. Applications: cranes, measuring structural stresses etc. (12-page brochure).—*W. C. Dillon & Co., Inc., 14620 Keswick St., Van Nuys, Calif.*

CIRCLE 197 ON READER-SERVICE CARD

CURVE FOLLOWER

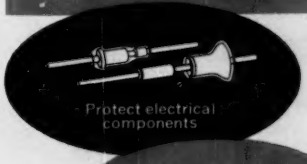
New Model FGE 5048 Data-Trak guides automated processes by interpreting function curves drawn as a

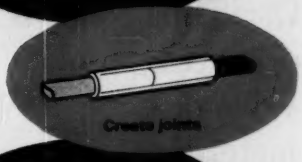
double line with ordinary pencil on common graph paper. Pencilled chart, mounted on revolving drum, guides servo-driven capacitive probe that follows centerline between plotted lines. Rotation time adjusts from 300 to 10 sec/rev (12 to 360 cycles/hr).—*Research, Inc., Box 6164, Minneapolis 24, Minn.*

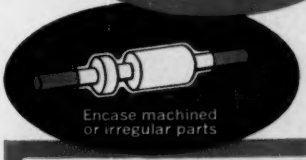
CIRCLE 198 ON READER-SERVICE CARD

See how much more you can do with

EXPANDED TEFLON* TUBING







HOW IT WORKS: PF expands tubing mechanically to a much larger diameter. In use, tubing is positioned and heated to gel point. On cooling, it recovers its original diameter, shrinking to form a tight fit over the part it encloses.

Advantages of **EXPANDED TUBING:**

- CLAMPS TIGHTLY any inserted object, including irregular shapes and other Teflon tubing
- CHEMICALLY INERT
- LOW PERMEABILITY
- LOW COEFFICIENT OF FRICTION
- TOUGH AND FLEXIBLE
- NON-FLAMMABLE
- EXCEPTIONAL ELECTRICAL PROPERTIES

PF Expanded Tubing is made in all popular thin and standard wall sizes, in 11 colors and it can be printed and cut to the lengths you require.

Send for a free sample and try it yourself or let us show you how it works and what it can do for you.

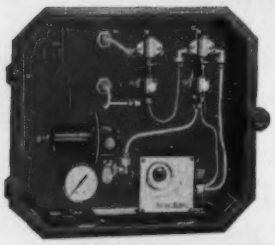
JUST WRITE, WIRE OR PHONE.

PENNSYLVANIA FLUOROCARBON CO., INC.

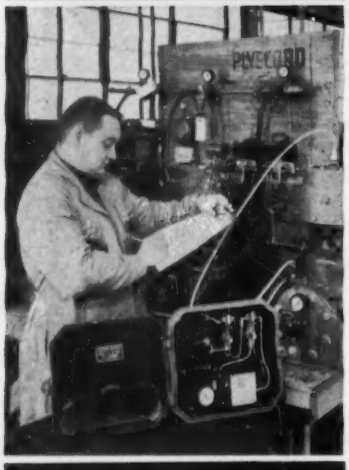
1115 N. 38th Street, Philadelphia 4, Pa.
PHONE: EVergreen 6-0603 TWX: PH 252

*Du Pont Reg. T.M.

CIRCLE 69 ON READER-SERVICE CARD



New Servo-Gauge Oscillator controls cycle testing of valve diaphragm material



This test set-up at Hills-McCanna Company, Chicago, Illinois, demonstrates the flexibility of the Servo-Gauge Oscillator. Here, diaphragm type valves are undergoing repetitive pressure-impulse cycling to determine suitability of diaphragm materials.

The Oscillator, of all-pneumatic design which simplifies installation and eliminates electrical connections, can be set for a wide range of predetermined cycle rates and pressure signals.

Write for Bulletin P-20; Associated Control Equipment, Inc., P.O. Box 136, Coraopolis, Pa.

CIRCLE 160 ON READER-SERVICE CARD

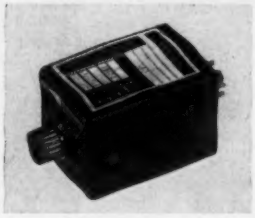
LOOK-UP SYSTEM

New electronic Rapid Access Catalog System operates from external

standard keyboard to project cataloged information from 16-mm film onto integral viewing screen. Example of use: For 400-page catalog (25,000 items in alphabetical order), key first 3 letters of item, and page containing item is projected on screen in 1.5 sec.—*Ferranti Electric Inc.*, 95 *Madison Ave., Hempstead, L. I., N. Y.*

CIRCLE 202 ON READER-SERVICE CARD

ELECTRONIC TIMER

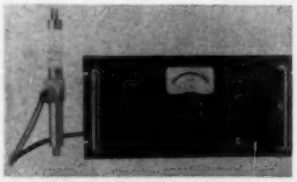


New TR-302 miniature transistorized electronic timer has selection of timing ranges and physical mounting. Units are plug-in with DPDT 5-amp resistive contacts and operate on 115-v ac.—*Syracuse Electronics Corp., Box 566, Syracuse 1, N. Y.*

CIRCLE 203 ON READER-SERVICE CARD

THERMAL FLOWMETER

New Model FMP-1 Thermal Flowmeter features stainless steel obstruc-



tionless flowcell without moving parts. Sensing elements external to flow stream and isolated from it by welded seams are useful for measuring flow of corrosive or radio-active liquid, liquids under high pressure or at high temperatures, or liquids requiring sanitary handling in chemical and food processing industries.—*Flow Measurements Corp.*, 10506 *Wheatley St., Kensington, Md.*

CIRCLE 204 ON READER-SERVICE CARD

The *Mastergauge* GROUP

and companion "Master-test" group for extreme services requiring the ultimate in accuracy and stamina.

Right *Quality* GROUP

also for tough services, but less severe than the conditions served by the "Mastergauge"

Gauge *Standard* GROUP

for the general run of gauge services. Marsh quality and accuracy at a moderate price.

for every need

Within these three comprehensive Marsh groups you have the world's widest (yes, and wisest) selection of pressure gauges. These groups of gauges are not *grades* ...they are *kinds*...the MARSH kind... which means that each gauge, within the scope of its rated use, is the BEST of its kind!

Pick the right Marsh Gauge and you have the best answer to your gauge problem.

Ask for latest data

MARSH INSTRUMENT COMPANY

Division of Colorado Oil & Gas Corporation, Dept. 42, Skokie, Ill. Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada. Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas.

MARSH

CIRCLE 70 ON READER-SERVICE CARD

BREAKTHROUGH!

100 Mc/s *Direct* Decimal Counting

Announcing a major advance in the art of counting . . .

Eldorado's Model 1050 **Solid State** Gated Counter — a triple purpose instrument for

- **100 Mc/s Direct or Gated Counting of random or continuous events**
- **Time Interval Measurements with 10 nsec resolution***
- **Frequency Measurements without heterodyne conversion to 100 Mc/s***

BASIC DATA

Counting and Frequency Measurement

STORAGE 10^9 counts (9 digits)
MAX. COUNTING RATE 100 Mc/s
DOUBLE PULSE RESOLUTION Better than 10 nanoseconds
TYPICAL INPUT PULSE REQUIREMENT +4 volts into 50 ohms
TYPICAL START/STOP PULSE REQUIREMENT —4 volts into 50 ohms

For Time Interval Measurement

EXTERNAL TIME REFERENCE Trigger requirements same as for input pulse above or will operate on 5 volt peak-to-peak 100 Mc sine wave

APPLICATIONS—The multipurpose Model 1050 is particularly suited for use in weapon or satellite systems, advanced electronic measurements, and nuclear research. Among specific areas of application are studies of missile velocity, acceleration and trajectory; space vehicle tracking; shock wave investigations; radar, telemetering, and communications; frequency stability, phase, and phase shift measurements; pulse width, rise, fall and duty cycle measurements; semiconductor studies; astronomical measurements; nuclear flight time, coincidence, and particle burst studies.

NEW LOGIC—KEY TO 100 Mc/s—The high counting rate of Eldorado's 100 Mc/s instrumentation is made possible by new decimal counting logic developed by Eldorado engineers—specialists in nanosecond pulse techniques.

For details on the new logic, contact your Eldorado engineering representative for Bulletin D-1050, or write us direct. Demonstrations at your convenience. Please Address Dept. 54.

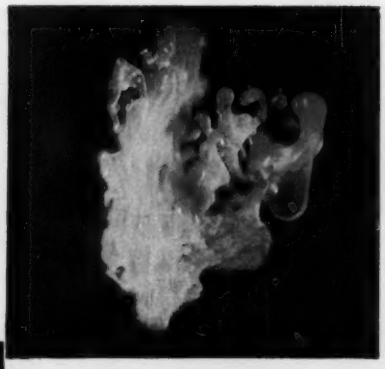
*When used as a time interval meter, Model 1050 requires an external oscillator for time reference; when used as a frequency meter, it requires an external time base. Eldorado can supply both. The Eldorado Model 1060 Time Interval Meter with same resolution has a built in oscillator for time reference.

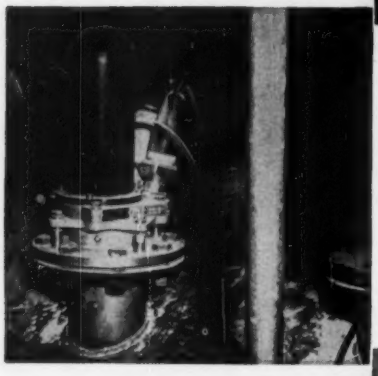
Eldorado Electronics

2821 Tenth Street • Berkeley 10, California • THornwall 1-4613

CIRCLE 72 ON READER-SERVICE CARD

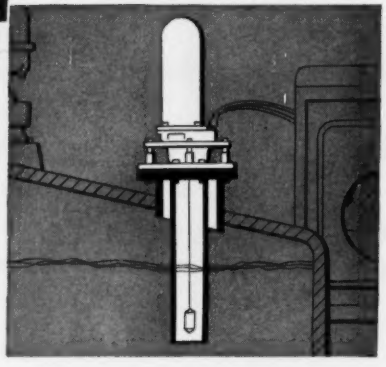
YES, NOW VISCOSITY





CAN BE CONTINUOUSLY

PROCESS CONTROLLED



WITH THE

BROOKFIELD VISCOMETRAN

UNDER actual process conditions, the Brookfield Viscometran accurately and continuously measures, records and controls viscosity. Readily mounted and integrated in existing processes, the Viscometran offers significant economic advantages over other methods of indicating degree of reaction, degree of polymerization or determination of process end point.

Viscosity is very likely a variable that is fundamental in your process. For complete information about how the Brookfield Viscometran can provide continuous "in process" measurement of this product dimension for you, write—

THE WORLD'S STANDARD FOR VISCOSITY MEASUREMENT AND CONTROL

Brookfield

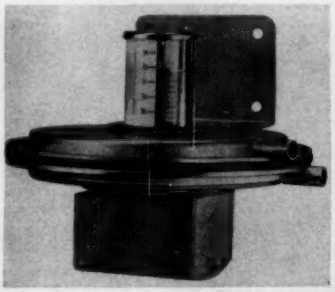
ENGINEERING LABORATORIES, INCORPORATED

STOUGHTON 316, MASSACHUSETTS

BROOKFIELD VISCOMETRANS NOW SUCCESSFULLY USED FOR CONTROLLING: Asphalt • Caramel • Cement slurries • Durezresin-acetone slurries • Gluten slurries • Lignum-based polymers • Molten P_2S_5 • Paper coatings • Polystyrene • Polyurethane resins • Ureaformaldehyde resin

CIRCLE 73 ON READER-SERVICE CARD

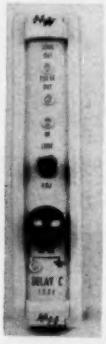
DIFFERENTIAL PRESSURE SWITCH



New 1630 Series Differential Pressure Switch features extreme low settings, visual setting, high reliability. One model may be set to open circuit on pressure differential increase of 0.05" of water and to close on decrease of 0.03". Repetitive accuracy within 1%. Bulletin E-30.—*F. W. Dwyer Mfg. Co., Dept. IT-5, Box 373, Michigan City, Ind.*

CIRCLE 208 ON READER-SERVICE CARD

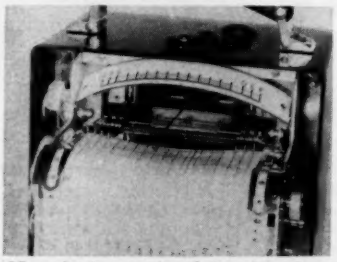
DUAL OUTPUT VARIABLE DELAY LOGIC MODULE



New Model 1321 Delay C Data Bloc is variable from 0.1 μsec to 0.7 sec in 5 incremental steps (using front-panel selector) and continuously variable between steps (using front-panel vernier control). For digital systems where adjustable and/or long delays are required. Level output and pulse output available.—*Harvey-Wells Electronics, Inc., 14 Huron Dr., Natick, Mass.*

CIRCLE 209 ON READER-SERVICE CARD

ANALOG-CHRONOGRAPH RECORDER

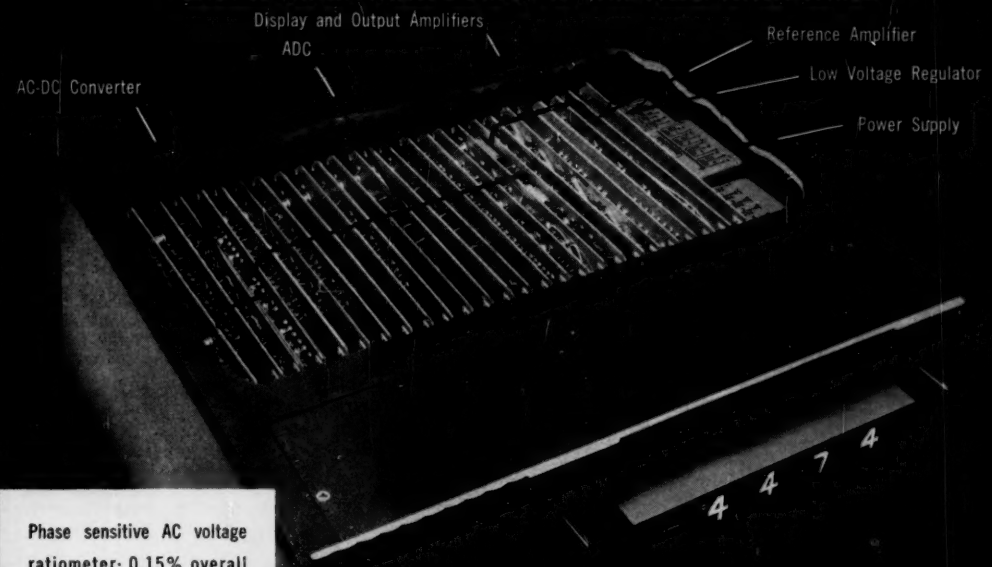


New instrument relates two types of recordings on one 6" strip chart. Center 3" portion of chart is analog measurement of dc μamp, ma, mv, volts; ac volts and amperes, etc. Six chronograph pens synchronize on-off time of related events or timing pulses with analog record by marking in enlarged margins of chart.—*Esterline-Angus Instrument Co., Box 596, Indianapolis 6, Ind.*

CIRCLE 210 ON READER-SERVICE CARD

26 standard Adage modules, assembled to serve a special purpose

This digital a-c ratiometer, designed to customer specifications for Nike Zeus checkout systems, typifies the Adage way with special purpose devices.



Phase sensitive AC voltage ratiometer; 0.15% overall accuracy; 100 independent conversion per second; front panel display of sign plus 4 octal digits; 13 bit pure binary parallel output, with special voltage and current swings.

Adage design and production talents have been applied successfully to tailoring and delivering equipment for:

- analog-to-digital conversion
- production test and inspection
- data acquisition, reduction and analysis
- automatic checkout
- process control
- computer linkage

Adage assures rapid and economic design and delivery of special equipment with a variety of input-output functions:

AC-DC Conversion	***Differential Input***
Multiplexing	***Limit Test***
High Input Impedance	***Min-Max Peak Reading***
Programmed Ranging and Mode Selection	***Magnetic Tape, Paper Tape, Typewriter & Printer Outputs***

For high-speed, reliable, and accurate systems components engineered to *your* specifications, contact . . .

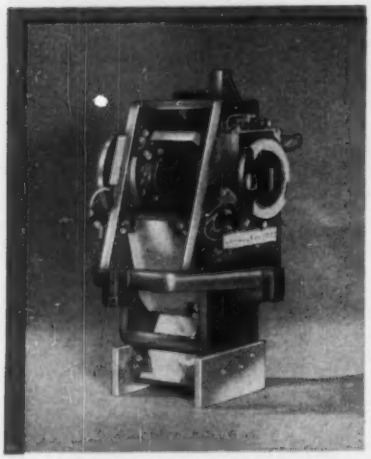
Adage INC

292 MAIN ST., CAMBRIDGE 42, MASS.

West Coast Facility: 1145 East Ash Avenue, Fullerton, California

CIRCLE 74 ON READER-SERVICE CARD

PRECISE STAR TRACKER



A celestial navigation system called for a tracking device capable of establishing a line of position within an accuracy of 300 feet. Kollmorgen came up with a constant deviation elevation system that positions a movable mirror, in relation to the fixed elements, to a repeatable accuracy of better than 5 parts in a million.

This compact package represents a combination of highly precise optical and electronic units in a housing only 6 x 6 x 10 inches. Kollmorgen's project from concept to installation, it is a typical demonstration of the company's scientific, engineering and manufacturing skills in optics, electronics, mechanics. Example: the precision optics (a prism and two mirrors) are of Kollmorgen manufacture. So, too, are the Inland torque motor*, the gearing and other precision-machined parts.

Our motive in this message: Kollmorgen offers proven capabilities in optics, electronics and precision machining of metal components . . . capabilities which could solve your problems in missile tracking, fire controls, navigation, or . . .?

Present us with a problem.

*Product of Inland Motor Corporation of Virginia, a Kollmorgen subsidiary.

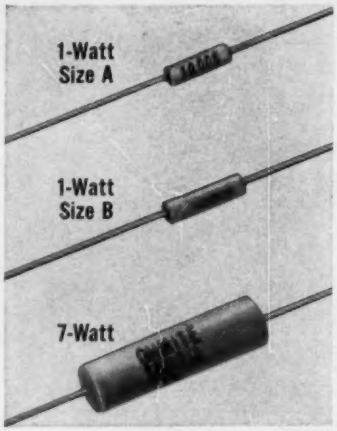
Dept. 12-1

KOLLMORGEN CORPORATION
NORTHAMPTON, MASSACHUSETTS

CIRCLE 75 ON READER-SERVICE CARD

ICS NEW INSTRUMENTS

RESISTORS AND RHEOSTATS



Two new ratings, 1-watt and 7-watt, of molded wirewound resistors have been introduced. In the 1-watt rating: size A is 0.417" long x 0.50" dia, range to 4500 ohms; size B is 0.542" long x 0.150" dia, range to 6500 ohms. 7-watt size is 1.218" long x 0.323" dia, range to 30,000 ohms. Bulletin 153.—*Ohmite Mfg. Co.*, 3642 *Howard St., Skokie, Ill.*

CIRCLE 211 ON READER-SERVICE CARD

SEMICONDUCTOR TEST SET

New portable precision lab semiconductor test set, Type 310, measures standard "h" parameters of transistors at constant emitter current up to 100 ma, and constant collector voltage to 30 v; rectifier diodes with up to 100-ma forward current; Zener diodes, 65 ma available at 10 v, 50 ma at 15 v, and 30 ma at 20 v. Leakage and reverse current test potentials range to 600 v.—*Owen Laboratories, Inc.*, 55 *Beacon Place, Pasadena, Calif.*

CIRCLE 212 ON READER-SERVICE CARD

shift phase **FAST** with AM&C **FAZE-BOX**

Here is a low-cost precision instrument that lets you shift phase from 0 to 180° in a matter of **seconds.** No more time-consuming construction of make-shift circuits every time a new phase shift problem arises — AM&C FAZE-BOX is there when and where you need it. **Compact, easy-to-use, dependable.**

Input Voltage Range	Up to 30 volts rms
Frequency Range	25 to 10,000 cps
Input Impedance	15,000 ohms approx.
Output Voltage	Same as input
Controls	Fixed-Phase selector Coarse phase selector Fine phase vernier
Size	3"hx6½"wx3¾"d overall
Weight	1.5 lbs.
Price	$69.50
Delivery	Immediate

YOU CAN ORDER ONE TODAY

AMERICAN MEASUREMENT & CONTROL, INC.
240 Calvary St., Waltham 54, Mass.
TWinbrook 4-6212

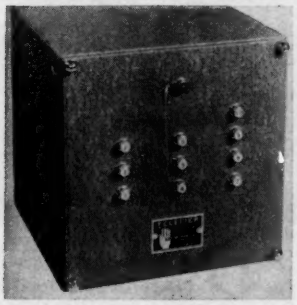
CIRCLE 76 ON READER-SERVICE CARD

PORTABLE TAPE RECORDER

New portable Magnetic Tape Recorder, Model CP-100, is a complete 7- or 14-channel recording and reproducing system. Can be operated in its mobile case or mounted in standard 19" rack. It accommodates either ½" or 1" wide tape on 10½" reels, and provides six tape speeds from 1⅞ to 60 ips, as well as fast-forward and rewind. Direct or FM-carrier recording is employed.—*Ampex Data Products Co., Dept.* 511-1, 934 *Charter St., Redwood City, Calif.*

CIRCLE 213 ON READER-SERVICE CARD

NUMERICAL READOUT



New TELEFIER remote readout device scans all burner circuits to pinpoint trouble spot, "telegraphs" signal to numerical readout indicator. Units serve up to 23 burners.—*Protection Controls, Inc.,* 7317 *N. Lawndale Ave., Skokie, Ill.*

CIRCLE 214 ON READER-SERVICE CARD

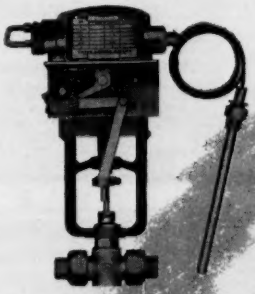
FLATBED TAPE RECORDER

New Model DS-7 Flatbed Tape Recorder and Playback Unit is lightweight, direct-recording, and self-contained. Time correction can be introduced on playback; reliable operation provided by simplified plane-surface head carriage system. Requires 12-v battery.—*Electro-Technical Labs, Div. of Mandrel Industries, Box* 13243, *Houston* 19, *Texas.*

CIRCLE 215 ON READER-SERVICE CARD

The Rugged, Efficient, Thrifty Line of

"WORK HORSE" CONTROLS



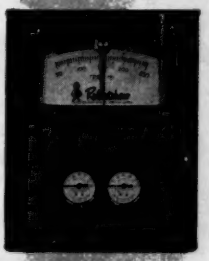
1110 FultroMatic . . . complete temperature control system in one air-actuated package: temperature controller, pneumatic control valve, positive valve positioner.

1004 Series . . . closest temperature control in the self-ops field. Available in 40° adjustment ranges from −35°F to +425°F. (Plus 8 other styles.)

CV Series . . . diaphragm- or bellows-actuated control valves for precise control of fluid flow in commercial or industrial applications. Pneumatic or hydraulic operation.

They look rugged, they *are* rugged . . . yet every Robertshaw control is designed for *performance* first. Plant engineers in leading industries continually specify Robertshaw for workhorse controls that stay on the job year after year with higher efficiency, lower maintenance.

Get the facts on dependable, moderate priced Robertshaw controls for your particular field. Ask for catalog A-AL.



1150 Series . . . an indicating pneumatic controller with greatest field serviceability; proportional action (5% to 200%), automatic reset, fully compensated thermal system.

1135 FultroPilot . . . for positive remote control through air signal to control valve, damper actuator, etc., from fast-response thermostat.

Robertshaw

MR. CONTROLS

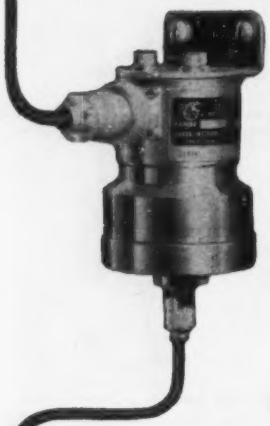
Robertshaw-Fulton Controls Company

FULTON SYLPHON DIVISION • KNOXVILLE 1, TENNESSEE

CIRCLE 77 ON READER-SERVICE CARD

TABER TELEDYNE® SYSTEMS

For Electrical Measurement of PRESSURES, actuate indicators, recorders and controllers.



Because the TELEDYNE can be DIRECTLY cable-connected to the TABER INDICATOR (or ANY quality recorder or controller) as far as ½ mile away, it becomes your best choice for measuring all gas and liquid pressures. No Auxiliary equipment is required, as the Taber Indicator has its own pre-amplifier and power supply. In addition, (1) Teledyne has an easy clean-out pressure cavity feature, (2) handles extremely corrosive media such as fuming NITRIC ACID and FLUORINE, (3) Bonded Strain Gage construction makes it relatively insensitive to vibration or shock, (4) has built-in overload protection at no extra cost. Repeatability 0.1%, Linearity 0.25%, Hysteresis 0.25%, Ambient Temperature —100° to +275° F., 1 Millisecond response, Pressure ranges up to 10,000 PSI.

Write for Illustrated Literature

TABER INSTRUMENT CORPORATION

"Where the Accent is on Accuracy & Reliability"

Section 243 107 Goundry St. North Tonawanda, N. Y. Telephone: NX 3-8900 TWX-TON 277

Taber®

Model 236 Pressure Indicator

Indicator-Recorder

Indicator-Controller

CIRCLE 78 ON READER-SERVICE CARD

PHILADELPHIA
THERMAL CONTROLS AND THERMOMETERS

Specify! THE BEST!

A half century of experience is back of every instrument we make. You get assured accuracy and long dependable performance when you specify "Philadelphia." Our specialized staff will be glad to discuss your problem in our field.

SEND FOR CATALOG 110

Since 1905

PHILADELPHIA THERMOMETER CO.

4401 N. Sixth St. • Philadelphia 40, Pa.

CIRCLE 79 ON READER-SERVICE CARD

- ELIMINATE DELAYS!
- KEEP YOUR OPERATING COSTS WHERE THEY SHOULD BE!

PORTABLE 40-POUND BENCH MODEL 106

Here is a speedy, economical 2 or 3-dimensional engraver used by thousands of dollar-conscious companies. It features 5 positive, accurate pantographic ratios; ball bearing spindle with 3 speeds up to 14,000 rpm. Is supplied with one copy carrier that accepts all standard master type sizes. Will actually work up to 10" by any width. Height of pantograph and position of cutter are continuously adjustable.

You Make Your Own Engraved Nameplates!

MODEL D-2 HEAVY-DUTY 2-DIMENSIONAL

Pantograph for milling, drilling and engraving.

Vertical adjustment of copy table automatic with Pantograph. Features: unobstructed on 3 sides to take large work; micrometer adjustment for depth of cut; ball bearing construction throughout; spindle speeds up to 26,000 rpm for engraving or machining; vertical range over 10"; ratios 2 to 1 to infinity — master copy area 26" x 10"

NEW MODEL D2-201 PNEUMATIC ATTACHMENT

for use with Model D2 Pantograph Engraver to rapidly drill holes in printed circuits by tracing templates. Drills as many as 100 holes per minute. Equipped with foot switch; spindle air cylinder; regulating valve and pressure gauge; filter and oiler. It's ready to use as soon as it's attached to an air compressor

Write or call for full details and prices.

GREEN INSTRUMENT COMPANY, INC.

Dept. 83, 295 Vassar St.

Cambridge 39, Mass. Tel. ELiot 4-2989

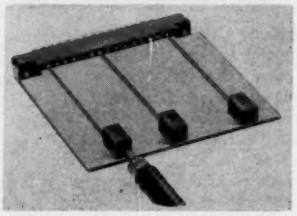
CIRCLE 80 ON READER-SERVICE CARD

SERVO AMPLIFIER

New Model 122 solid state servo amplifier is 20-w 60-cps general purpose unit for dc and ac inputs. A 100-mv input will cause 115-v 60-cps output to rated load. Unit is self protecting from excessive input.—*K-F Products, Inc.*, 3100 *E. 43rd Ave., Denver 16, Colo.*

CIRCLE 216 ON READER-SERVICE CARD

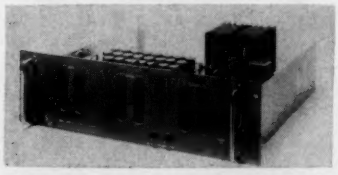
TEST POINT CONNECTORS



New test point connectors can be located on printed circuit board or in critical printed circuit applications for easy test takeoff points. Single or multiple contact types with 4 to 42 test points for right-angle dip soldering to printed circuit boards. Variety of molding compounds. Brochure TP1060.—*Electronics Div., De-Jur-Amsco Corp.*, 45-01 *Northern Blvd., Long Island City* 1, *N. Y.*

CIRCLE 217 ON READER-SERVICE CARD

TAPE SEARCH UNITS



New series of tape search display units operates in conjunction with 4 time code generators. ZA-841 reads time code supplied by ZA-801 24-bit BCD time code generator. ZA-842 reads time code supplied by 17-bit binary time code generator, ZA-802. ZA-843 reads time code of 20-bit binary ZA-803 time code generator. ZA-850 reads time code from ZA-810 time code generator which produces a 36-bit BCD days, hours, minutes and seconds code.—*Electronics Engineering Co. of California*, 1601 *E. Chestnut Ave., Santa Ana, Calif.*

CIRCLE 218 ON READER-SERVICE CARD

LOW BUDGET...

GOW-MAC CHROMATOGRAPHY COMPONENTS

...FOR FAST DELIVERY

MINIMIZE VPC DETECTOR DOWN TIME!

CUSTOMER FIELD SERVICE

FILAMENTS IN MATCHED PAIRS
(A) 2-inch leads
(B) 12-inch leads
(Minimum order 5 pairs)

HARNESSES—
Two matched pairs, improved wiring in balanced bridge with terminal panel, 12-inch electrical leads and four tube nuts.

UP-GRADE EARLY MODELS!

FACTORY REBUILDING OF YOUR THERMAL CONDUCTIVITY DETECTORS

Detectors cleaned, re-filamented and bench-tested on specified carrier (0-5 mv. recorder or 0-1 mv. recorder as required).

BIG SIGNAL LOW NOISE RELIABLE!

PANCAKE POWER SUPPLIES

Solid state, 20 volts at 500 milliamperes. Helipot attenuator or decade stepping switch. Quick, easy hook-up.

ALSO AVAILABLE—

- Thermal Conductivity Cells for Gas Analysis
- Micro-Cell for use with ¼" Packed Columns, VPC
- Gas Blenders for Automatic Mixing of Gases
- Temperature Regulated Cells
- Gas Density Detectors for VPC
- Portable and Panel Instruments

VISIT BOOTH 406—PITTSBURGH CONFERENCE ON ANALYTICAL CHEMISTRY AND APPLIED SPECTROSCOPY, FEB. 27 TO MARCH 3.

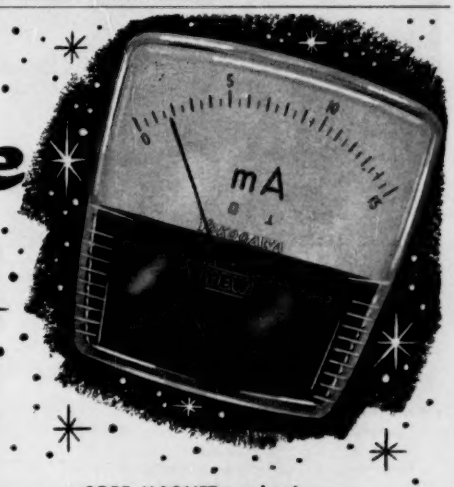
GOW-MAC INSTRUMENT COMPANY

100 KINGS ROAD, MADISON, N. J., U. S. A. • Telephone: FRontier 7-3450

GAS ANALYSIS BY THERMAL CONDUCTIVITY SINCE 1935

CIRCLE 81 ON READER-SERVICE CARD

The Prince is here...



The Royal line in small panel meters... the PRINCE is a triumph in modern industrial design.

Thoroughly planned, developed and field tested with features that have made YEW panel instruments superior throughout the world.

- *CORE MAGNET mechanism—except Movable Iron Type*
- *EZ-READ dial—extra long scale*
- *LOC-QWIK one screw mount*
- *YEW RELIABILITY SINCE 1915*

- *AVAILABLE in a complete line of 2½", 3½" and 4" models both AC & DC*

YEW **YOKOGAWA ELECTRIC WORKS, Inc.**
40 Worth Street • New York 13, N. Y.

CIRCLE 82 ON READER-SERVICE CARD

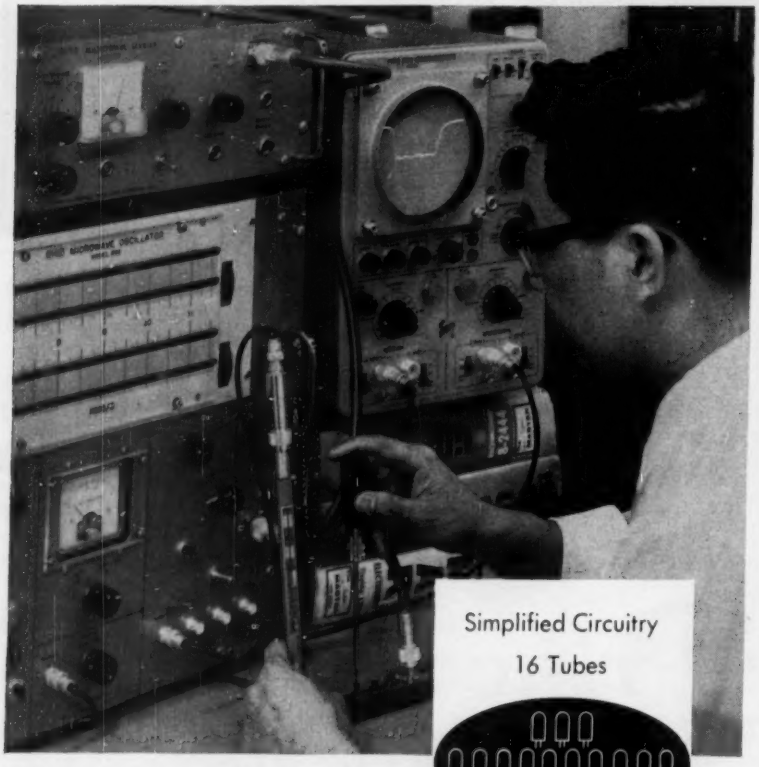
NEW GENERAL-PURPOSE OSCILLOSCOPE

The Tektronix Type 503 has the operational features you are most likely to want in a dc-to-450 kc oscilloscope. It is engineered for your convenience... inherently simple and reliable, unusually light and relatively small for a 5-inch oscilloscope.

Tektronix standards of quality in engineering, construction, and service apply to this new instrument. You can see and operate the Type 503 now—call your Tektronix Field Engineer for a demonstration.

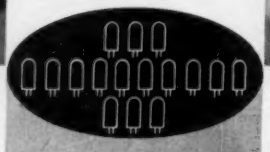
Adjusting insertion characteristics of an X band filter with an ALFRED Model 626 Microwave Oscillator and a Tektronix Type 503 Oscilloscope. Oscillator output is held constant to within ± 1 db over the 8 to 10 kmc range with an ALFRED Model 708 Microwave Leveler. The sharp, bright presentation and vertical-amplifier stability of the Type 503 Oscilloscope permit continuous long-term adjustment of the filter.

Photo courtesy of ALFRED ELECTRONICS, Palo Alto, California



Simplified Circuitry

16 Tubes



EXCEPTIONAL ACCESSIBILITY FOR MAINTENANCE

CONDENSED SPECIFICATIONS

Identical Horizontal and Vertical Amplifiers
Frequency response—dc to 450 kc (3db down).
Sensitivity—1 mv/cm to 20 v/cm, calibrated.
Differential input and constant input impedance at all attenuator settings.

Wide Sweep Range
1 μsec/cm to 5 sec/cm, calibrated.
X2, X5, X10, X20, and X50 magnification.
Versatile triggering includes automatic operation.

3-KV Accelerating Potential
8-cm by 10-cm viewing area.

Size and Weight
13½" high, 9¾" wide, 21½" deep—about 29 lbs.

Price.....$625 f.o.b. factory

A specification folder with full-color illustrations is available from your Tektronix Field Office.

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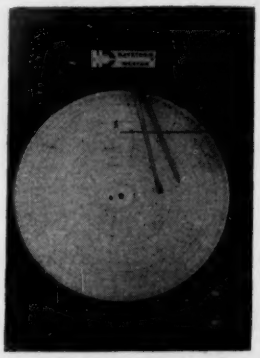
In Europe please write Tektronix Inc., Victoria Ave., St. Sampsons, Guernsey C.I., for the address of the Tektronix Representative in your country.

CIRCLE 68 ON READER-SERVICE CARD

ICS NEW INSTRUMENTS

TEMP RECORDER-CONTROLLER

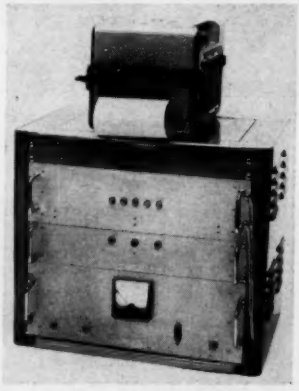
New Model 7813 mechanical recorder is available in two types: Electric On-Off Temperature/Pressure



Recorder Controller, non-contact type which may be combined with single or dual thermometers or pressure recorders and indicators; Proportional Electric Temperature Recorder Controller which covers complete range (—100° to 1000°F) of liquid and mercury filled thermal systems.—*Daystrom, Inc., Weston Instruments Div.*, 614 *Frelinghuysen Ave., Newark* 12, *N. J.*

CIRCLE 219 ON READER-SERVICE CARD

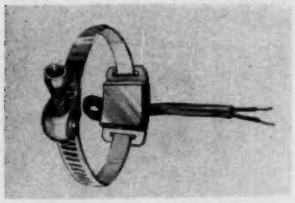
THERMOCOUPLE CALIBRATOR



New Thermocouple Input Conditioning and Calibrating System Model 16T-100 features automatic 4-step calibration simultaneous or sequential, calibration-set scale for direct reading of temperatures into low impedance galvanometer regardless of input lead length or resistance, accommodation of all thermocouples with reference junctions, individual channel span and damping resistors, individual calibration level resistors. —*B. & F Instruments, Inc.*, 3644 *N. Lawrence St., Phil.* 40, *Pa.*

CIRCLE 220 ON READER-SERVICE CARD

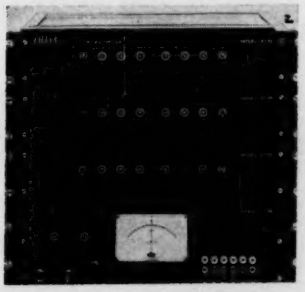
SURFACE THERMOMETERS



Two new RdF Strapon Surface Thermometers operate from —100° to 500°F, and intermittently from —300° to 575°F. Can be immersed in fluids or molded into units where inside temperature is to be measured. Are commonly strapped to pipe to make measurements without shutting down process, interrupting flow or cutting pipe.—*Arthur C. Ruge Associates, Inc., Hudson, N. H.*

CIRCLE 223 ON READER-SERVICE CARD

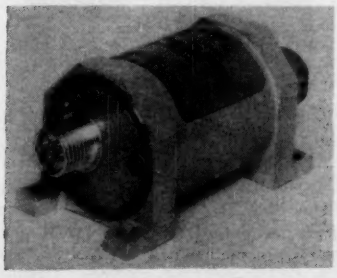
ELECTRONIC MULTIPLIER



New dual electronic multiplier Model 3735 offers single-quadrant multiplication and squaring with accuracies of 0.01%. Four-quadrant multiplication accuracy is 0.05% full scale. Units are available in 2, 4, or 6 channels and require no external power supplies or amplifiers to work with analog computing equipment.—*Donner Scientific Co., 888 Galindo St., Concord, Calif.*

CIRCLE 224 ON READER-SERVICE CARD

PRESSURE TRANSDUCER



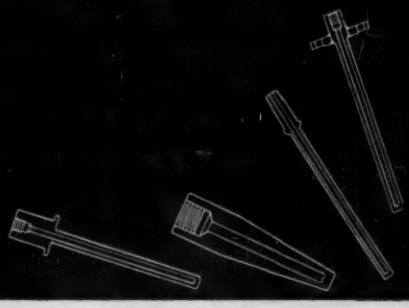
New P2-3000 Series variable-reluctance dc pressure transducers feature small size and low power requirement. Type P2-3076, for pressure ranges up to 5000 psig, weighs 5 oz and requires 3 ma at 28-v dc for 0- to 5-v dc -output.—*Daystrom Wiancko Engineering Co., 255 N. Halstead St., Pasadena, Calif.*

CIRCLE 225 ON READER-SERVICE CARD

WHEN DEPENDABILITY IS A REQUIREMENT...

TRINITY

Trinity Thermowells assure the greatest degree of dependability through the most careful material selection and certification, plus outstanding manufacturing and inspection techniques. Trinity Thermowells are products of the world's leader and pioneer in the design, development, and manufacture of thermowells.



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Every standard Trinity Thermowell is packaged in an easy-to-store box that maintains factory-fresh condition of the well. Complete identification is provided on end panel for on-the-shelf selection.

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Trinity maintains a complete stock of thermowells for fast customer service. Orders filled and shipped within 24 hours.

Plus TRINITY THERMOCOUPLES

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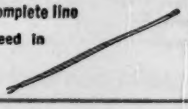

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NEW IMPROVED RESISTORS
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Includes both ac and dc generators and detectors which have been specifically designed for use with the bridge, thus assuring adequate sensitivity for attaining specified accuracy throughout the measurement range.

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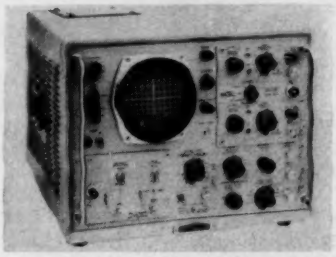
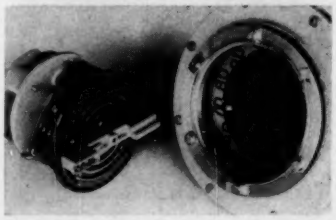
15-Mc OSCILLOSCOPE



New Model 160B oscilloscope uses a series of newly-designed time axis plug-in units: Model 166C display scanner; Model 166D sweep delay generator; Model 162A dual trace amplifier (20mv/cm sensitivity). Provides 24 calibrated sweep times, 0.1 μsec/cm to 5 sec/cm, with ±3% accuracy. A sweep magnifier increases the fastest sweep to 0.02 μsec/cm.—*Hewlett-Packard Co.*, 1501 *Page Mill Rd., Palo Alto, Calif.*

CIRCLE 226 ON READER-SERVICE CARD

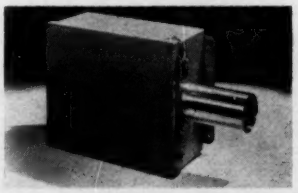
DIGITAL DATA SYSTEM



New ADVisor Data System uses shaft-position digitizer (photoelectric type), shaft velocity digitizer (photoelectric-counting type), pulse rate digitizer, logic unit, counter module, and Perfograph recorder (using electronic-incinerated perforated tape).—*Advanced Instrument Corp.*, 700 *S. Fourth St., Richmond, Calif.*

CIRCLE 227 ON READER-SERVICE CARD

INFRA-RED RELAY

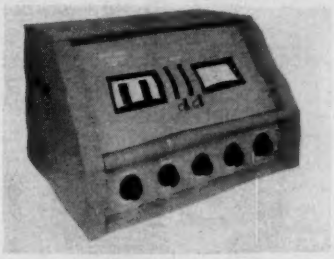


New Model 5121 Infra-Ray Relay adjustable heat-sensing device can be used remotely from hot-forming processes to actuate water sprays, take-up reels, pouring devices, furnace doors, conveyors, etc. Optical system and detector element provide 12-in² discriminate field of vision 20 ft from relay. Set for maximum sensitivity, relay is energized by a 1-in³ object from 10 ft, at 1100°F and moving at 6 ips.—*Daystrom Inc., Weston Instruments Div.*, 614 *Frelinghuysen Ave., Newark* 12, *N. J.*

CIRCLE 228 ON READER-SERVICE CARD

GAS ANALYZER-MONITOR

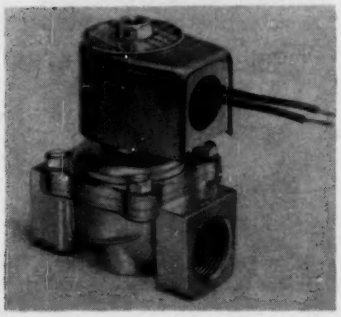
New Therma Bridge gas analyzer-monitor for continuously scanning atmospheres surrounding missile fuels



measures hazardous concentrations down to 0-10 ppm Unsymmetrical-dimethyl hydramine (UDMH) or 0-100 ppm Nitrogen Tetroxide in air full scale. Monitor triggers alarms and emergency ventilating systems when air becomes dangerous.—*Industrial Instruments Engineering Corp., 89 Commerce Rd., Cedar Grove, N. J.*

CIRCLE 229 ON READER-SERVICE CARD

SOLENOID VALVE



New compact solenoid valve with ¾" pipe connections, forged brass body and bonnet and soft composition disc, handles gas to industrial and commercial boilers and furnaces or in any low pressure control system.—*Automatic Switch Co., Florham Park, N. J.*

CIRCLE 230 ON READER-SERVICE CARD

TRANSISTORIZED POWER SUPPLY

New transistorized power supply, Type SCRT 60V-7.5A-1, supplies regulated dc at high current, has output of 0-60v dc at 0-7.5 amp (both sides floating with respect to ground). Dynamic response less than 200 mv transient spike for 100 μsec for a ± 1-amp step change in load current and less than +1v transient spike from 7.5 to 0 amp.—*Del Electronics Corp., 521 Homestead Ave., Mount Vernon, N. Y.*

CIRCLE 231 ON READER-SERVICE CARD

READ

differential or gauge pressure *quickly... accurately... reliably*

Wallace & Tiernan Aneroid Dial Indicators give you fast response, high sensitivity, reliable accuracy.

Whether you're in testing, manufacture, or research, there's a W&T Dial Indicator that's ideal over a wide range of differential or gauge pressures.

A W&T Aneroid Dial Indicator guarantees you:

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- ★ Light weight, small size
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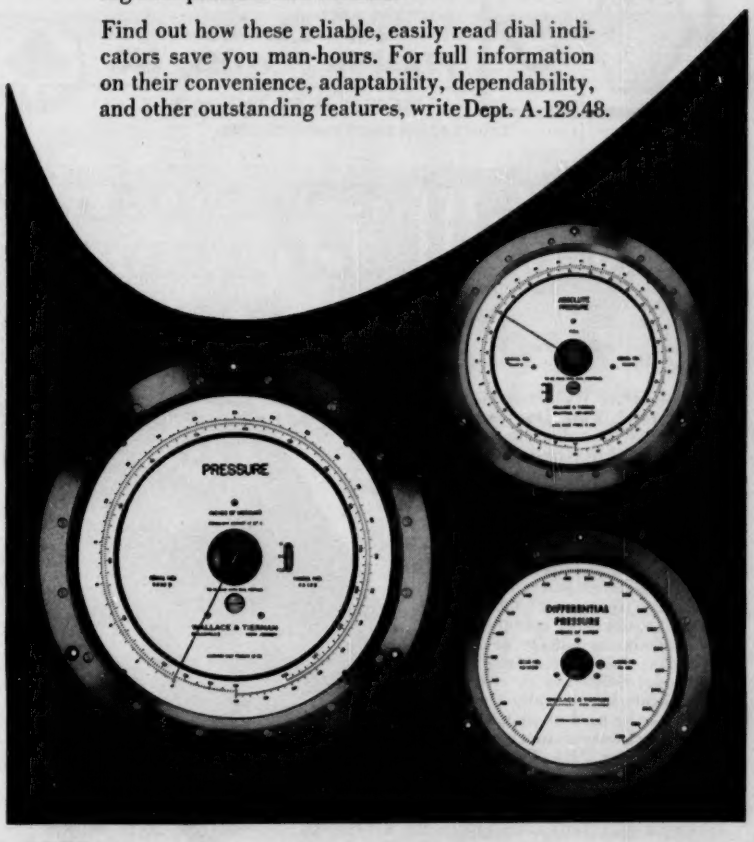
W&T Aneroid Dial Indicators are also furnished as compound gauges with zero center for measuring both pressure and vacuum.

Find out how these reliable, easily read dial indicators save you man-hours. For full information on their convenience, adaptability, dependability, and other outstanding features, write Dept. A-129.48.



WALLACE & TIERNAN INCORPORATED

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PYRAMID "INSTRUPACK"

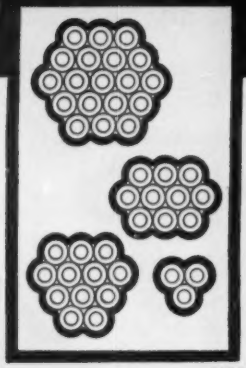
(TUBING BUNDLES)

POLYETHYLENE TUBES ENCLOSED IN VIRGIN PVC (VINYL) SHEATH

STANDARD

Tubing—¼" O.D. x .040" Wall, .045" or .062" Sheath

Tubing—⅜" O.D. x .062" Wall, .045" or .062" Sheath



Tough vinyl outer sheath with excellent chemical atmospheric resistance. Inside tubes are Polyethylene available in standard colors with pair of telephone wire leads. Lengths to requirements.

STOCK POLYETHYLENE TUBING—¼" O.D. x .040" wall and ⅜" O.D. x .062" wall, in standard colors.

PLASTIC COATED METAL TUBING—standards and specials to order.

Write for Bulletin PPI-59.

PYRAMID PLASTICS, INC.

556 W. Polk St., Chicago 7, Ill.

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Otto Wolff STANDARD GUARDED VOLT BOX

The Otto Wolff Standard Guarded Volt Box is the original box described and illustrated in NBS-RP1419. It has been in continuous production by Otto Wolff since 1924. The Model S42 is the unit shown in RP1419 and has the characteristics described therein. The Model SG42 is a later development offering a ratio accuracy of 0.005%. On special order models with a maximum voltage of 1500 volts are available. The Model SG42 has all critical resistors hermetically sealed. It may be used in air *without* internal temperature control. Write for PRL Technical Note 332 VB for details of the world's most complete and accurate volt boxes, shunt boxes and voltage dividers.

MODEL S 42

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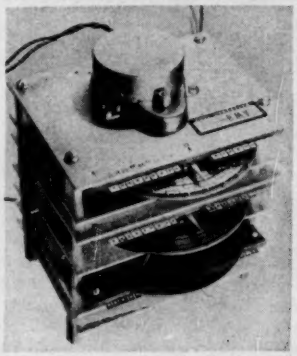
BINARY CODE GENERATORS

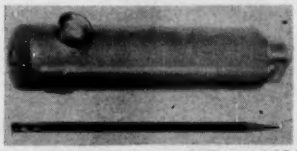
New Binary Time Code Generators for data processing, transmitting and computing systems, and automatic



control systems are basically shaft position encoders that convert analog data from shaft position angles into digital output signals. Many types of output code, timing periods, drive systems, and control and accessory equipment can be combined to satisfy requirements.—*A. W. Haydon Co., Waterbury, Conn.*

CIRCLE 232 ON READER-SERVICE CARD

TUBULAR PHOTOELECTRIC UNIT



New Tubular Control Type 22LB5, contains transistorized, printed circuit in flashlight-type cylinder (7½" x 1⅝" dia) with conduit hub threaded for ½" pipe for simple direct mounting in any position. With matching light source Type 40CE1, relay operates with light impulses as short as 0.015 sec at light beam ranges to 20'.—*Photoswitch Div., Electronics Corp. of America 1 Memorial Dr., Cambridge, Mass.*

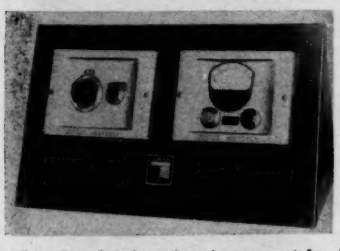
CIRCLE 233 ON READER-SERVICE CARD

SUB-PANEL DIGITAL READOUT

New Series 120$_{00}$ miniature Digital Readout, mounted ¼" behind lucite viewing screen, rear-projects digit onto screen. Digits (⅝" high) visible from any angle; no mounting holes on readout panel.—*Industrial Electronic Engineers, Inc., 5528 Vineland Ave., N. Hollywood, Calif.*

CIRCLE 234 ON READER-SERVICE CARD

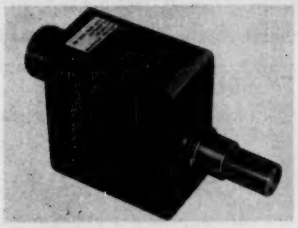
OPTIMUM LOAD CONTROLLER



New Loadtrol maintains preset load on drive motor of process equipment, machine tools or web handling machinery to increase or decrease feed rate, flow rate, or brake pressure. Matches motor load to control signal through shunt or current transformer in motor circuit.—*Jordan Controls, Inc., 3235 W. Hampton Ave., Milwaukee 9, Wis.*

CIRCLE 235 ON READER-SERVICE CARD

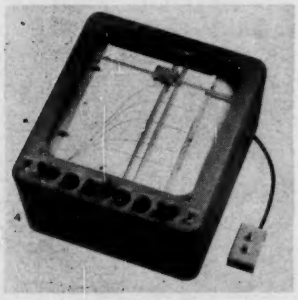
LIQUID LEVEL INDICATOR



New liquid-level indicator uses an electronic control and sensing element combined as a unit to measure lubricants and other liquids on aircraft and industrial engines where heat and vibration prevent use of conventional indicators.—*Electronics Dept., D-40, Hamilton Standard, United Aircraft Corp., Broad Brook, Conn.*

CIRCLE 236 ON READER-SERVICE CARD

PEN LIFTER XY RECORDER

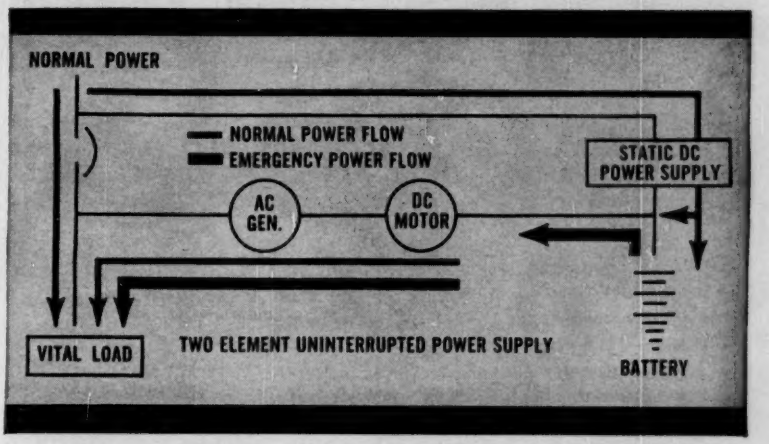


New Model HR-93 XY Recorder has electric pen lift mechanism allowing point plotting, family curve tracing and rapid non-recording pen indexing. Lifter can either be operated with hand-held manual control box or can be tied into test circuitry for automatic operation.—*Houston Instrument Corp., Box 22234, Houston 27, Texas.*

CIRCLE 237 ON READER-SERVICE CARD

Kearfott Uninterrupted Power Systems...

FOR CONTINUOUS, UNVARYING POWER AT ALL TIMES



Typical applications: *Nuclear Reactors • Power Distribution • Digital Computers • Process Control • Communication Systems*

Kearfott Uninterrupted Power Systems are vital in applications where any interruption in AC power can cause serious loss or delay. These continuous power systems, which can be tailored to a variety of requirements, put an end – once and for all – to the problem of varying or intermittent prime power.

In one representative system arrangement, an AC generator is driven by a DC motor which derives power from a regulated rectifier in parallel with a long-life storage battery. When power fails or varies the rectifier, which normally supplies power to the DC driving motor, is disconnected and the battery provides surge-free power to the motor—*in zero time*. When prime power is restored, the system automatically reverts to standard operating conditions and the battery is restored to readiness by the main battery charger.

Also available in 2 and 3 unit systems operating in parallel with or isolated from the line, Kearfott's compact uninterrupted power systems also provide audible and/or visual alarms to indicate over- and under-voltage, overload or ground conditions.

Generator ratings to 150 KVA 60 and 400 cycles, single and polyphase.

Frequency, voltage, and transfer regulation as required by the application.

For complete data on the wide variety of arrangements available, write to

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GENERAL PRECISION, INC.

Little Falls, New Jersey

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INSULATION TESTER
Model L-5

- *Expanded Scale*
- *Quick response*
- *Silent Generator*
- *CORE MAGNET mechanism indicator*
- *Housed in light metal case*
- *Optional accessory of leather carrying case and leads*

PORTABLE PRECISION AC-DC INSTRUMENTS

Rated accuracy 0.5 of 1% of full scale

- *DC, AC and High Frequency Voltmeter and Ammeter*
  DC: Model MPF
  AC: Models SPF, CPF
  HF: Model TPF
- *Wattmeter*
  DC-AC: Model DPB-1W

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"EVABRITE" FIRST SURFACE MIRRORS — High reflecting hard metal coatings—direct reflection without parallax.

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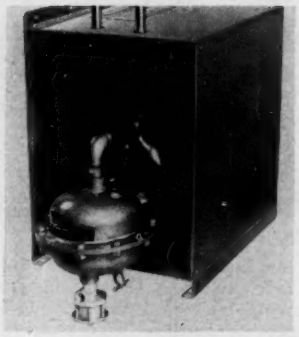
CIRCLE 91 ON READER-SERVICE CARD

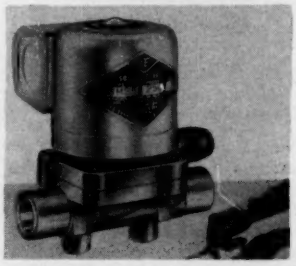
AIR DRYER



New Series-E non-cycling Air Dryer (rated capacity of 10 scfm at 100 psig) air conditions and ventilates control systems, printing press and other pneumatic feeds, processing and production lines, etc. Unit dries air and gases by mechanical refrigeration, needs no cooling water, and eliminates ambient temperature variance problems.—*Hankison Corp., College & Pike, Canonsburg, Pa.*

CIRCLE 238 ON READER-SERVICE CARD

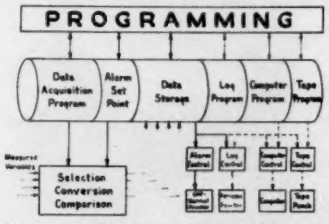
SOLENOID VALVES



Complete line of solenoid valves has epoxy-clad coils which make them impervious to condensation, frost, oil, gasoline, fluid spray, etc.—*Jackes-Evans Mfg. Co., 4427 Geraldine Ave., St. Louis 15, Mo.*

CIRCLE 239 ON READER-SERVICE CARD

DRUM-PROGRAMMED DATA SYSTEM



New solid-state Bailey 750 information system features magnetic-drum programming and digital computer for performing all computing functions. It continuously scans, linearizes, ranges and digitizes all inputs and stores digital values of each measurement on magnetic drum.—*Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.*

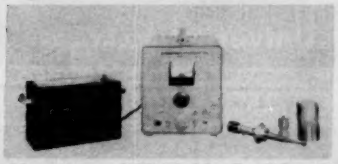
CIRCLE 240 ON READER-SERVICE CARD

ON-STREAM ANALYSIS-CONTROLLER

New AutoAnalyzer for on-stream control of boiler phospate feed and determination of boiler silica content automates power plant chemistry. Its proportioning pump handles as many as 8 reagents simultaneously. Pumping rates: from 0.32 to 3.50 ml/min.—*Technicon Controls, Inc., Chauncey, N. Y.*

CIRCLE 241 ON READER-SERVICE CARD

ULTRASONIC GENERATOR

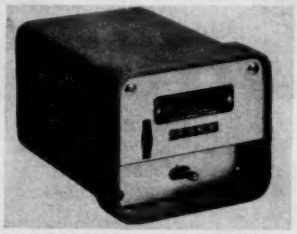


New Inson PW highly-flexible 100-w ultrasonic generator has connections for any of 10 output impedances. Frequency may be 10 to 100 kc or greater. Applications: ultrasonic welding, soldering, splicing cleaning, drilling, etc.—*International Ultrasonics, Inc.*, 1697 *Elizabeth Ave., Rahway, N. J.*

CIRCLE 242 ON READER-SERVICE CARD

WORD COUNTER

Operating at 60, 75, and 100 wpm speeds, new counter automatically measures message traffic on teletype-

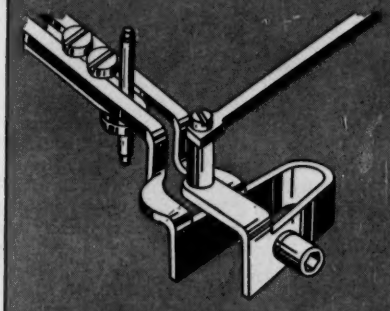


writer circuits, presents numbers on illuminated face. Features built-in transistorized line relay permitting direct connection into printing telegraph circuit with no inductive effect and negligible signal distortion.—*Western Apparatus Co., Div. of Comptometer Corp.*, 5600 *Jarvis Ave., Chicago* 48, *Ill.*

CIRCLE 243 ON READER-SERVICE CARD

HEISE GAUGES

MICRO-SLIDE



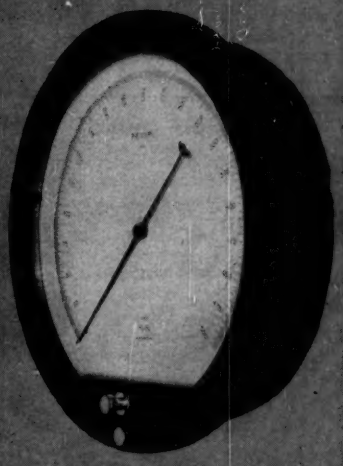
Highly favorable reaction among gauge users has followed the development of the Heise Micro-Slide adjustment. Systematic field recalibration of batteries of Heise gauges may now be directly and precisely effected with minimum time loss.

Calibration adjustments as fine as .0005 inches in the effective length of the sector slide may be quickly and conveniently applied.

Periodic recalibration of gauges may also be reduced as a result of the damping effect of the spring loaded adjustment which protects the setting from shock and vibration.

CONVENIENT PRECISION RECALIBRATION

The Micro-Slide comprises a spring loaded micrometer screw controlling the position of the link pivot. This screw may be conveniently adjusted with a standard Allen wrench. A flat spring cushions the assembly and protects the setting from shock or vibration.



Dial Sizes	FULL SCALE READING (P.S.I.)						
	0-15 to 0-5,000 inclusive	Over 0-5,000 and including 0-20,000	Over 0-20,000 and including 0-30,000	0 to 40,000	0 to 50,000	0 to 75,000	0 to 100,000
8½"	$183.50	$205.50	$238.50				
12"	$209.50	$231.50	$264.50	$275.50	$286.50	$336.50	$386.50
16"	$255.50	$277.50	$310.50	$321.50	$332.50	$382.50	$432.50

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for accurate pressure measurement in ounces or inches of water

Standard dials reading in inches of water, ounces, centimeters or millimeters up to 10 P.S.I. All Marshalltown diaphragm gauges are extremely sensitive and accurately measures very low pressures.

Let Marshalltown answer your gauge problems . . . write for information and prices.

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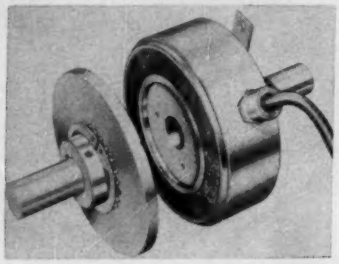
CIRCLE 94 ON READER-SERVICE CARD

STATIONARY MAGNET CLUTCH

New 5.5 SMR Stationary Magnet Clutch has stationary magnet, ball-bearing mounted, for ease in assembly and alignment. Coils can be wound for up to 115-v dc max, and insulated with Class "A" through "H" insulation. Has 45 lb-ft torque rating; can be converted to magnetically set brake by securing rotor to magnet body; available in split and thru-shaft arrangements.—*Stearns Electric Corp., 120 N. Broadway, Milwaukee, Wis.*



CIRCLE 244 ON READER-SERVICE CARD

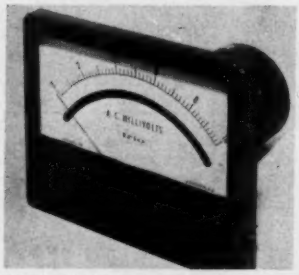
VIBRATION EXCITER

New Model VS-10 is for production vibration testing of small components requiring accurate control and analysis of high frequency vibration. Frequency range 20 cps to 27 kcps; power supply 75 w continuous without air cooling, 200 w intermittent with 10-psi air supply; nominal force output 20 lb.—*Vibrasonics, Inc., 10 High St., Boston, Mass.*

CIRCLE 245 ON READER-SERVICE CARD

PANEL AC VTVM

New Model 130-1 AC VTVM has standard ranges in single-scale sensitivities ranging from 10mv to 300v, input impedance of 1 megohm, and 1% accuracy for measurements from 50 to 50,000 cps.—*Trio Laboratories, Inc., Plainview, L. I., N. Y.*



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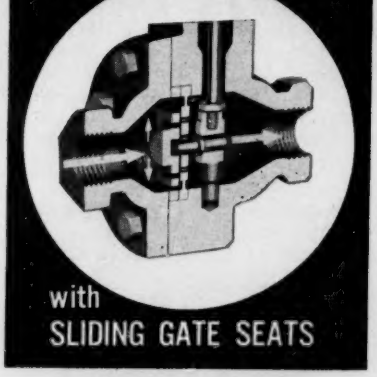
CONTROL VALVES



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Complex design can be a needless luxury in Control Valves. Look at the simplicity of the OPW-Jordan Control Valve! Yet you'll get close control and far lower costs.

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LABORATORY STANDARD

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- Flat response to 100 megacycles/sec.
- Ideal for checking V T V M's
- Calibrate on D.C. or 60 cycles/sec.
- Can be certified by Bureau of Standards
- Separate thermocouple units available in ranges 1 volt, 3 volts and 10 volts
- Also units for 30 volts and 100 volts with less frequency range

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with the improved
PYRO OPTICAL PYROMETER

- Accurate
- Direct reading
- Rugged
- Standard ranges 1400° F to 7200° F

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CIRCLE 98 ON READER-SERVICE CARD

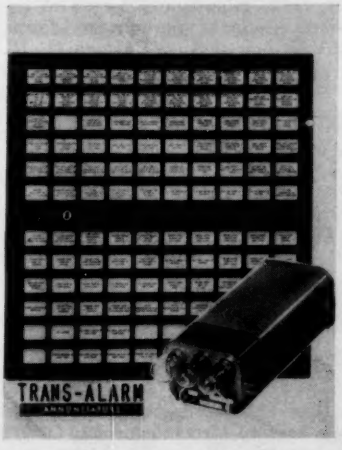
NEW INSTRUMENTS

SYNCHRO TRANSMITTERS

Two new series of synchro transmitters for applications where remote pressure sensing is required: TL Series for low pressure measurements from 0-10 to 0-350 psi are available in 115 and 26 volt designs for use at 400 and 60 cycles and feature a dual aneroid capsule design; TH Series for higher pressure measurement from 0-600 through 0-20,000 psi uses helical Bourdon tube element.—*Servonic Instruments, 640 Terminal Way, Costa Mesa, Calif.*

CIRCLE 247 ON READER-SERVICE CARD

SOLID STATE ANNUNCIATOR



New Trans-Alarm solid state annunciator offers circuitry for every alarm function. Each annunciator point is plug-in assembly making every signal station independent.—*Tigerman Engineering Co., 4332 N. Western Ave., Chicago 18, Ill.*

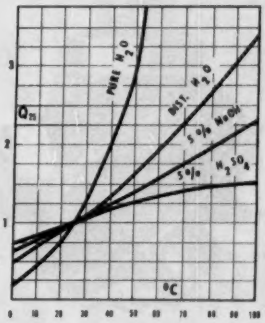
CIRCLE 248 ON READER-SERVICE CARD

CHATS ON CONDUCTIVITY

ACCURATE TEMPERATURE COMPENSATION

The overall accuracy of an electrolytic conductivity system is governed to a larger extent by the accuracy of its temperature compensator than by any other single factor...and probably ...by all other factors combined.

A prime requisite for high accuracy in conductivity measurements is a good match between the temperature coefficient of conductivity of the solution under test, and the characteristics of the temperature compensator. A small departure multiplied by a large number of °F can produce an impressively large error.



The above curve demonstrates the extent to which the temperature-conductivity characteristics of four common solutions differ from each other. Q_{25}, shown as the vertical coordinate, is the ratio of the conductivity of a solution at t°C to the conductivity of the same solution at 25°C. A temperature compensator designed to match any **one** of these solutions would fail miserably if used for any of the others.

Industrial Instruments, for many years, has recognized the need for close matching of the temperature compensator to the service requirements of the conductivity equipment. Over 500 different manual temperature compensators and 200 automatic temperature compensators are immediately available for applications ranging from ultra-pure demineralized water to fuming sulphuric acid, and from 20°F to above 300°F.

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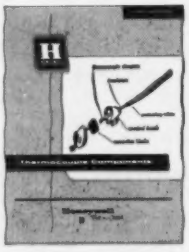
Industrial Instruments Inc.
89 Commerce Road, Cedar Grove, Essex County, N. J.

CIRCLE 99 ON READER-SERVICE CARD

THERMOCOUPLE COMPONENTS

Wires, insulators, protecting tubes, heads, blocks, connectors and miscellaneous components—supplied in countless combinations, for highest possible accuracy in any given application. Thermocouple components are among many thousands of accessories—all available from a single dependable source—that can help your instruments perform at their very best.



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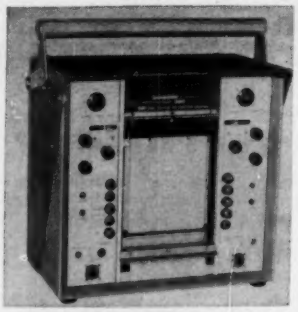
MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell

First in Control

CIRCLE 102 ON READER-SERVICE CARD

PORTABLE DIRECT WRITER



New Model 320 2-channel direct-writing oscillographic recorder with heated stylus is in portable case and has 2 current-feedback amplifiers (each with floating and guarded inputs). Response is dc to 125 cps at 10-div amplitude.—*Sanborn Co., Industrial Div., 175 Wyman St., Waltham 54, Mass.*

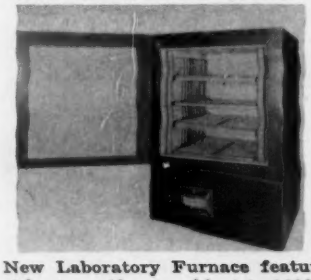
CIRCLE 249 ON READER-SERVICE CARD

RECORDING ANNUNCIATOR

New automatic recording annunciator records (prints) selected "off-normal" and "return to normal" conditions at command of simple contact devices (switches and relays). Record includes specific condition and month, day, hour, minute and second of occurrence.—*Scam Instrument Corp., 3101 N. Lowell Ave., Chicago 41, Ill.*

CIRCLE 250 ON READER-SERVICE CARD

HIGH TEMP OVEN-FURNACE



New Laboratory Furnace features fast heat-up (from ambient to 1600°F in 30 min) and new high temp, compact insulation that reflects more than 90% of exposed radiant heat and allows increased hot chamber volume in smaller furnaces.—*Shampaine Scientific Co., 615 E. 1st Ave., Roselle, N. J.*

CIRCLE 251 ON READER-SERVICE CARD

Wiley BOOKS

DIGITAL APPLICATIONS OF MAGNETIC DEVICES

Sr. Editor: ALBERT J. MEYERHOFF, *Burroughs Corporation Research Center.*

Conceived and planned at the request of the Office of Naval Research, this book provides the necessary tools for magnetic circuit design. Both text and handbook, it describes theory, electrical design, logical design, and system design necessary for the development of digital systems using the toroidal permanent magnet or magnetic core as the basic circuit element.

1960 604 pages $14.00

RADIATION PYROMETRY AND ITS UNDERLYING PRINCIPLES OF RADIANT HEAT TRANSFER

By T. R. HARRISON, Minneapolis-Honeywell Regulator Co.

Covers 1) theory; 2) principles; 3) details on construction and operation of instruments, in order to show desirable designs for different types of service, calibration characteristics, and the like.

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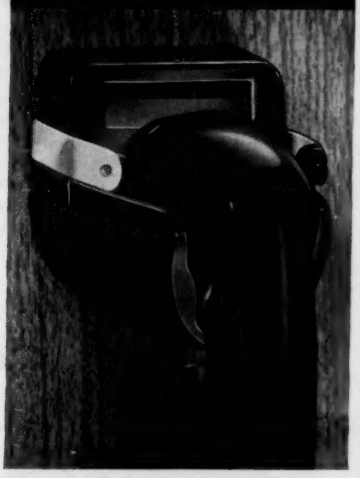
CIRCLE 100 ON READER-SERVICE CARD

NEW STROMBERG-CARLSON TELEPHONE HANDSET CRADLE



. . . for positive retention in all mobile applications

There's no jump, no sway—when a telephone handset is in the firm *grip of this new handset cradle* by Stromberg-Carlson.

Retaining clip spring assembly assures positive retention in any mobile application on land or sea, or in the air. Even extremely severe jars, jolts and vibrations fail to dislodge the handset.

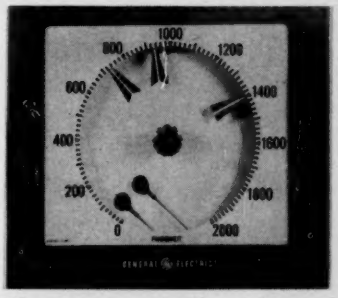
The cradle is strong and resilient, fits any Stromberg-Carlson handset. Different models provide varying switch combinations with 2 or 4 Form C contacts. All models available with or without the clip assembly.

Specifications on request. In Atlanta call TRinity 5-7467; Chicago: STate 2-4235; Kansas City: HArrison 1-6618; Rochester: HUbbard 2-2200; San Francisco: OXford 7-3630. Or write to Telecommunication Industrial Sales, 113 Carlson Road, Rochester 3, New York.

STROMBERG-CARLSON
A DIVISION OF
GENERAL DYNAMICS

CIRCLE 101 ON READER-SERVICE CARD

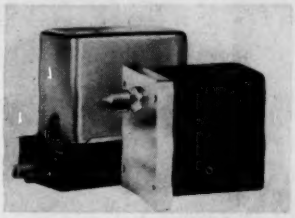
ROUND CHART RECORDER



New two-pen potentiometric round-chart recorder-controller is accurate to ±¼%. Measurement circuits may be either potentiometric or bridge-type, or combination. Zener diodes, which eliminate use of dry cells and standard cells, offer constant voltage reference accurate to ±0.05%.—*General Electric Co., Schenectady 5, N. Y.*

CIRCLE 252 ON READER-SERVICE CARD

PHOTOELECTRIC TACHOMETER



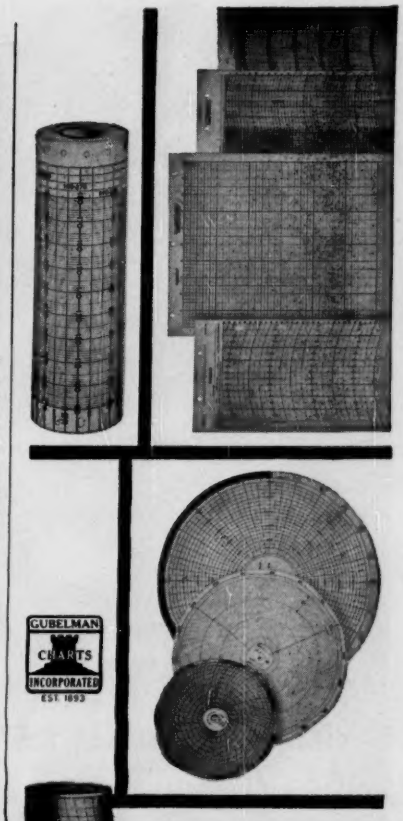
New photoelectric tachometer for precise digital measurement of shaft speeds, particularly on sub-fractional motors, uses integral light source, 60-segment rotating interrupter, photojunction cell, and special transistor amplifier. Measures any speed from 0 to 25,000 rps (25 kc) with required driving torque of 0.05 in-oz at 3600 rpm.—*Servo-Tek Products Co., 1086 Goffle Rd., Hawthorne, N. J.*

CIRCLE 253 ON READER-SERVICE CARD

TRANSISTORIZED TIMERS

New G-V Types 401 and 404 Transistorized Time Delays for prototype and general use have delay interval adjustable over 10 to 1 range, and five overlapping ranges that span 0.1 to 300 sec. Time delay determined by value of resistor connected between two external terminals. Repeatability of ±1% with nominal 28-v dc under constant operating conditions. Technical Bulletin 80.—*G-V Controls Inc., 101 Okner Parkway, Livingston, N. J.*

CIRCLE 254 ON READER-SERVICE CARD



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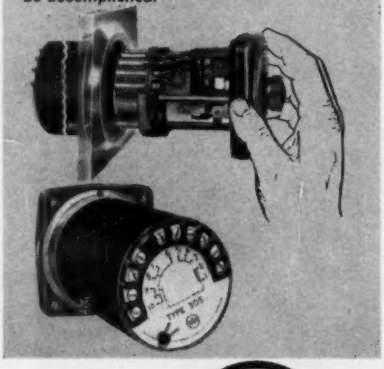
NEW QUICK-CHANGE "PLUG-IN" TIMERS

REMOVE AND REPLACE IN SECONDS

The new plug-in feature of the Atcotrol Reset Dial Timer permits fast, easy timer removal and replacement . . . keeps industrial process "down time" to a minimum because complete timer changes can be made instantly.

These Series 305 miniaturized timers control up to six individual load circuits, AC or DC, within variable timed intervals or sequences, with high repetitive accuracy. Able to perform 145 different circuit functions, they reset in less than 1/10 second, either stop or reset upon power interruption. As with all Series 305 timers, the plug-in model offers exclusive one-hole mounting.

WHEN INSTALLED, the plug-in model's plated, non-corrosive hex sockets engage plated banana plugs in a tubular case for positive spring pressure contact. A keyed guide pin aligns timer in its tubular enclosure, protrudes through rear to accept a snap-in cotter pin clip, assuring continuous full-contact engagement. This safety clip must be removed before unplugging a "hot" timer, so that only authorized persons can make timer replacements. An optional front-mounting clamp is available for installation where rear accessibility cannot be accomplished.



PLUG-IN CONVERSION KIT

Standard Series 305 timers will continue to be made available for applications where the plug-in feature is not desired. These timers and those already installed, however, can easily be converted in the field to plug-in models.

For complete specifications and a schedule of prices, contact your nearest ATC sales office. Request Bulletin N-141.

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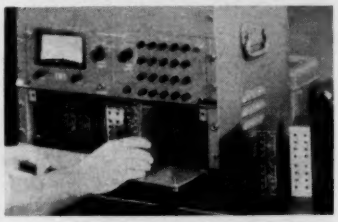
CIRCLE 103 ON READER-SERVICE CARD

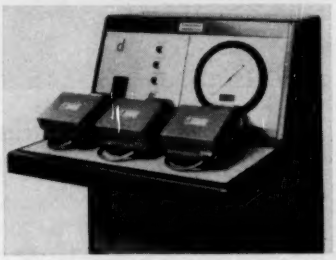
COMPUTER COMPONENTS



New "do-it-yourself" analog computing components combine for engineering and process control computing functions. TR-5 mounting unit, which holds up to 6 computing components and power supply, is prewired to accept 5 more dual amplifiers and has space for 5 more dual modules or 10 single linear or nonlinear computing components.—*Electronic Associates, Inc., Long Branch, N. J.*

CIRCLE 255 ON READER-SERVICE CARD

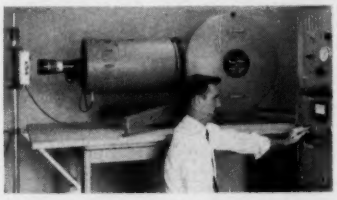
WEIGHING/RECORDING SCALE



New Dynaprint weighing and recording scale for conveyor lines records individual weights and totalizes automatically. Employs crossed-flexure, 3-point suspension system with hydraulic load-cell. Ranges available to 2000 lb. Catalog 200.—*Dynametrics Corp., Northwest Industrial Park, Burlington, Mass.*

CIRCLE 256 ON READER-SERVICE CARD

CONTINUOUS STREAK CAMERA



New Model 339 Sweeping-Image Camera, producing an uninterrupted 50" streak image on 35-mm film, can be used for documentation of randomly occurring events not suitable for synchronization with the instrumentation. Writing rate is 9 mm/μsec at max mirror speed of 2600 rps; time resolution, 5 x 10^{-9} sec; minimum total writing time, 145 μsec.—*Beckman & Whitley, Inc., San Carlos, Calif.*

CIRCLE 257 ON READER-SERVICE CARD

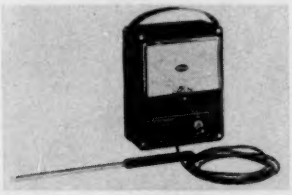
ANALOG/DIGITAL CONVERTER

New DIGISYN Type RD-13G shaft-position, optical (non-contact-

ing) analog-to-digital encoder provides 8192 (2^{13}) codes per revolution without gearing. Features modular plug-in components, self-contained spares that permit field servicing without special tools, provision for "go-no-go" testing remotely and for monitoring operation during a mission.—*Adcon Div., Wayne George Corp., 588 Commonwealth Ave., Boston, Mass.*

CIRCLE 258 ON READER-SERVICE CARD

PORTABLE TEMPERATURE INDICATOR

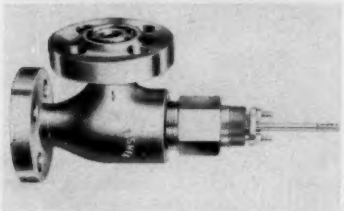


New Model 583 battery-powered Temperature Indicator has thermistor sensing probes and batteries having an estimated life of several thousand hours. Available in ten different ranges, from −30° to +350°F, and uses interchangeable probes for air, liquid and surface temperature sensing.—*Fenwal Inc., Pleasant St., Ashland, Mass.*

CIRCLE 259 ON READER-SERVICE CARD

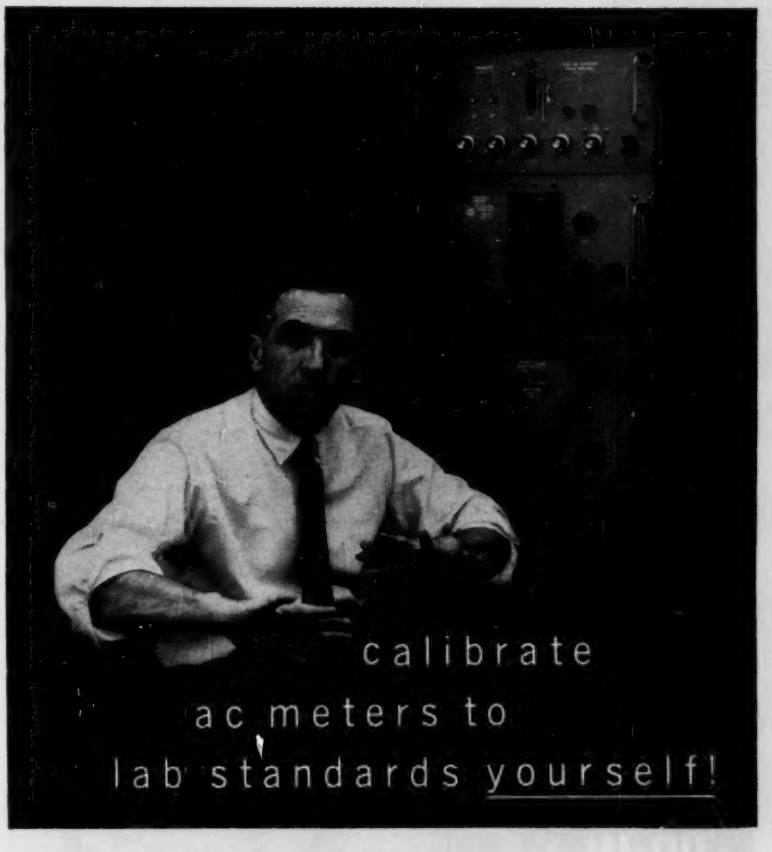
VALVE FLANGES

New integral flanged end connections on high pressure 1" and 2"



angle and globe cast steel valve bodies for oil and gas production, power plant installations and process industries have 1500 or 2500-lb ASA flanges.—*Fisher Governor Co., Box 307, Marshalltown, Iowa.*

CIRCLE 260 ON READER-SERVICE CARD



with this stable,

low-distortion ac power source

New from Krohn-Hite: this variable-frequency, 50 watt ac power source, with less than 0.01% amplitude stability and 0.1% harmonic distortion! The LDS-1500 offers a continuously-variable wide range of voltage and current — up to 1500 volts, and up to 12 amps, at *any* frequency from 20 cps to 20 kc.

Here is the long-desired combination of short-term stability and low distortion for calibration, by the comparison method, of all conventional indicating ac voltmeters and ammeters, and digital meters normally used for laboratory measurements.

Now you can calibrate your own meters at precisely the frequencies you require. Because of the push-buttons and vernier controls, frequency settings are positive, convenient, and resettable to better than 0.01%.

As a general-purpose variable frequency source of distortion-free, highly stable power, the LDS-1500 has many other applications. Quality-control testing for distortion or performance of components requiring a variety of power supply frequencies is simplified. The 50 watt power output is ample to supply test benches.

Send for full information on this unusual ac power source!

KROHN-HITE CORPORATION

580 Massachusetts Avenue • Cambridge 39, Mass.

Pioneering in Quality Electronic Instruments

CIRCLE 104 ON READER-SERVICE CARD

NEW INSTRUMENTS

ROLL CHART PAPERS

With new Perf-fold feature, roll chart papers can now be accordian-folded for filing, reference, etc. Perforations, too small to catch any pen, are stamped at 11¾" intervals across width of each roll of J-B Chart Papers in any width, single or multi-channel.—*Judson-Bigelow Sales Div., Techni-Rite Electronics, Inc., Box 3575, Providence 10, R. I.*

CIRCLE 261 ON READER-SERVICE CARD

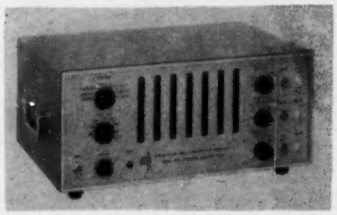
POSITION LEVEL INDICATOR

New Position Indicator provides continuous meter reading up to 10' of mechanical travel or fluid level. High and low contacts may be incorporated to operate remote warning lights or indicator.—*Gems Co., Inc., Sheppard Lane, Farmington, Conn.*

CIRCLE 262 ON READER-SERVICE CARD

20-Mc COUNTER-TIMER

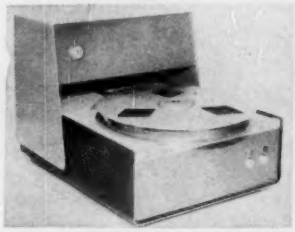
New all transistor Model 728A Counter-Timer is counter, time interval meter, and frequency/period meter; performs 7 functions selectable by front panel switch. Measures dc to 20 Mc, frequency; 0.1 μsec to 10^7 sec time interval; 0.1μsec, period. Sensitivity is 0.25-v rms; input impedance, 25-k ohms/volt.—*Computer-Measurements Co., 12970 Bradley Ave., Sylmar, Calif.*



CIRCLE 263 ON READER-SERVICE CARD

TAPE DEGAUSSER

New Type TD-2903 automatic tape degausser erases reeled tape to nominal 90 db below saturation level. Automatic time cycling assures uniform erasing. Power requirements: 117-v ac, single phase, 60 cps, approx 20 amp.—*Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.*

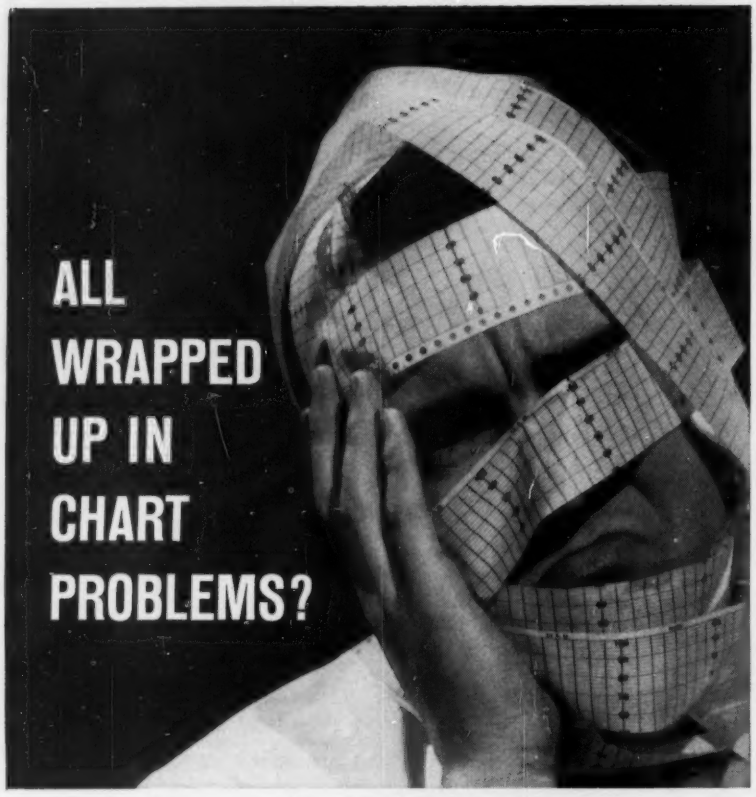


CIRCLE 264 ON READER-SERVICE CARD

HI-SPEED DIGITAL MODULES

New S-Pac plug-in, high-speed Digital Modules, Series S, have NAND circuitry and operate in frequency range from dc to 1 Mc. Feature glass epoxy cards (4½" high x 7" deep), etched circuits, anodozied aluminum frames with package identification and reliable 34-pin connectors.—*Computer Control Co., Inc., 983 Concord St., Framingham, Mass.*

CIRCLE 265 ON READER-SERVICE CARD



NO NEED TO BE... Bristol has met all the problems before . . . and has the answers!

If you need a special chart for that instrument you're designing, The Bristol Company's experienced staff of chart engineers stands ready to provide it for you . . . especially and expertly designed for your instrument . . . printed in one of the largest and best chart printing facilities in the country.

With almost 70 years of experience in the recording instrument business, Bristol really understands chart problems. What's more, Bristol's extensive facilities allow *fast* production of *all* types of charts—up to 32" wide in strip charts, 12" diameter for round charts. It doesn't matter how you intend to record—ink, hot stylus, electro-sensitive, light beam, or what have you—Bristol produces charts for all of them.

Get the complete Bristol chart story in new bulletin Y1906—yours for the asking. Write: The Bristol Company, 154 Bristol Road, Waterbury 20, Conn. O.11

BRISTOL ...for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

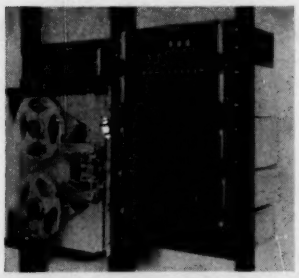
CIRCLE 105 ON READER-SERVICE CARD

RECORDING CAMERA

New continuous strip oscilloscope recording camera records radar cathode-ray tube impulses. Develops film in camera in 1 minute, no tanks of processing solutions. Unit features 70-mm Sonne strip camera, film lengths to 100'; fits std 5" oscilloscope.—*Chicago Aerial Industries, 550 W. Northwest Highway, Barrington, Ill.*

CIRCLE 266 ON READER-SERVICE CARD

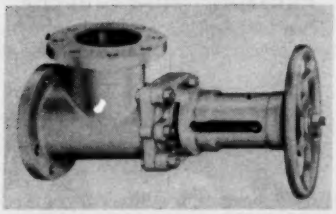
DIGITAL DATA SYSTEM



New Model 1610 Digital Data System acquires data at 5000 readings/sec or higher, has accuracy of better than 0.1%, uses only solid-state elements. One unit handles up to 100 input data channels, monitors and records data from entire plant, replacing chart and strip recorders.—*Communications and Control Corp., 14707 Keswick St., Van Nuys, Calif.*

CIRCLE 267 ON READER-SERVICE CARD

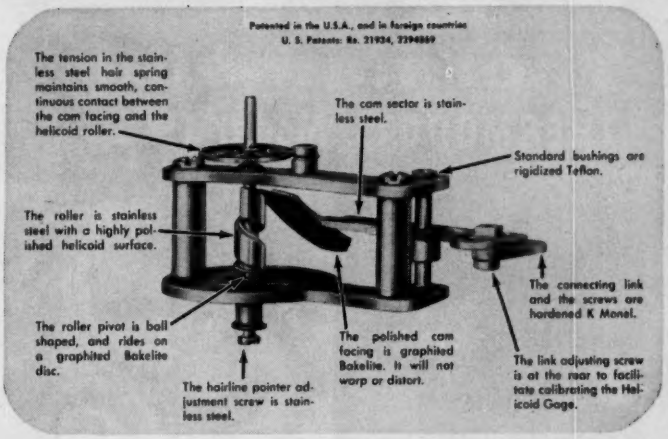
PISTON-TYPE ANGLE VALVES



New piston-type Angle Valves employ IMPERVITE impervious graphite for all internals in contact with corrosives. Available in 2, 3, 4, and 6" for temps. to 340°F, at pressures to 150 psi.—*Falls Industries, Inc., Solon, Ohio.*

CIRCLE 268 ON READER-SERVICE CARD

ACCO Helicoid Gage U.S.A.


Patented in the U.S.A., and in foreign countries
U. S. Patents: Re. 21934, 2394889
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides... *Sustained Accuracy... on the toughest jobs*

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details **Ask for Catalog DH-65**

HELICOID GAGES

Helicoid Gage Division • American Chain & Cable Company, Inc.

929-B Connecticut Ave., Bridgeport 2, Conn.

CIRCLE 106 ON READER-SERVICE CARD

To be shown for first time at ISA Show, January 17, 1961

Measures and controls temperature without contact

- Engineered for plant use: production, testing, quality control
- Lens focuses easily from 20″ to infinity, "sees" isolated spot size ⅛″ at 20 inches, 1 inch at 12 ft., etc.
- Non-parallax sight exactly defines spot size and identifies work area to be measured
- Broad temperature range: 210°F to 3300°F (higher range models optional)
- Pushbutton temperature calibration at control panel
- Ambient temperature compensation; emissivity adjustment from 0.1 to 1.0
- Sensitivity: 0.2% of temperature, e.g., 1°F at 500°F
- Response time: 0.3 second to 95% of full scale
- 0-10 mv. output for recorders, indicators, controllers (standard); internal relay control (optional)

For more information, write for Bulletin R-103.
See Thermodot at Booth 202, ISA Show, St. Louis, Jan. 17-19.

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DIVISION OF COMPTOMETER CORPORATION
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INFRARED COMPONENTS • INSTRUMENTS • SYSTEMS

CIRCLE 107 ON READER-SERVICE CARD

TAPE PUNCH

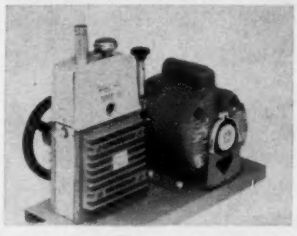
New Model TP-1 Tape Punch produces Alpha-Numerical coded tapes

for use as data input means for Carlton numerical control system. Standard 8-channel code is employed. All decimal codes plus alphabetic address codes S, T, U, W, X, Y, Z, as well as end line (carriage return) and tape feed codes can be produced.—*Carlton Controls Corp., 15 Sagamore Rd., Worcester 5, Mass.*

CIRCLE 269 ON READER-SERVICE CARD

SINGLE STAGE VACUUM PUMP

New S14 pump, recommended as a backing pump for oil or mercury dif-



fusion pumps or for economical roughing pump in complete vacuum system, uses internal vane principle with gas ballast. Pump is oil sealed and rated at 140 liters/min pumping capacity at atmospheric pressure; will pump down to guaranteed pressure of 10 microns of mercury. Booklet 322.—*Central Scientific Co., 1700 Irving Park Rd., Chicago, Ill.*

CIRCLE 270 ON READER-SERVICE CARD

PRESSURE TRANSDUCERS

Two new pressure transducers feature precycled, prestabilized, stand-

ardized operation with ranges from 200 to 2000 psi, 0.1% repeatability; operate during shocks in excess of 100g for 11 msec in any direction. Model 538B has flush-mounting diaphragm; Model 539B a threaded fitting for ¼″ flared tubing.—*Electro-Mechanical Research, Inc., Sarasota, Fla.*

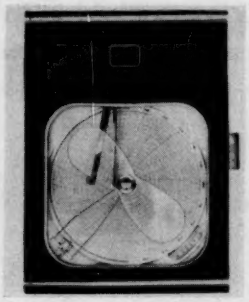
CIRCLE 271 ON READER-SERVICE CARD

COMPUTING SYSTEM

New G-20 Computing System features 40% increase in computing speed and 100% increase in magnetic tape speeds, solid-state electronics. Full-word clock cycle reduced to 6 μsec; average rate for single word, fixed point additions is now 83,000 per second. Reading and writing operations performed at 240,000 digits or 120,000 alphanumeric characters per second.—*Bendix Computer Div. of Bendix Corp., Los Angeles* 45, *Calif.*

CIRCLE 272 ON READER-SERVICE CARD

RECORDER CONTROLLER



New Series 500 single-case, time-program recorder-controller reduces panel-space requirements 50%. Recorder chart and program cam are independently driven, allowing program repetitions to be recorded on one chart. Either pneumatic or electronic control available.—*Bristol Co., Waterbury* 20, *Conn.*

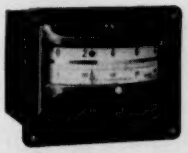
CIRCLE 273 ON READER-SERVICE CARD

CERAMIC

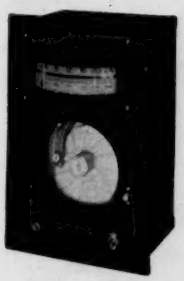
New Type AD-995 99.5% aluminum oxide ceramic was developed for radome applications. Characteristics: loss tangent at room temperature of 5.9 x 10^{-5} at 9200 Mc, flexural strength of 28,900 psi at 2000°F, extreme resistance to abrasion and corrosion.—*Coors Porcelain Co., 600 Ninth St., Golden, Colo.*

CIRCLE 274 ON READER-SERVICE CARD

Gardsman by WEST



STEPLESS Controllers (Model JSB) infinitely modulate electric heat. No on-off pulses. Prolongs heater-life, saves power. Exclusive manual switch, adjustable maximum and minimum input control. *Tubeless.* Compact. Least maintenance and operating attention required.



PROGRAMMER (Model JSBG Stepless) for the most *precise* control of temperature-time cycle, integrated by simply cut cam. Most compact. Can also control secondary operation at any point in the time cycle. Program Controllers are also available with other control forms:— (Off-On, Proportioning, etc.) Ask your West representative or write direct for Bulletins JSB and JG.

WEST Instrument CORPORATION
SALES OFFICES IN PRINCIPAL CITIES
4355 W. MONTROSE, CHICAGO 41, ILL.
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the trend is to WEST

CIRCLE 108 ON READER-SERVICE CARD

NOW IT'S OFF THE GROUND!

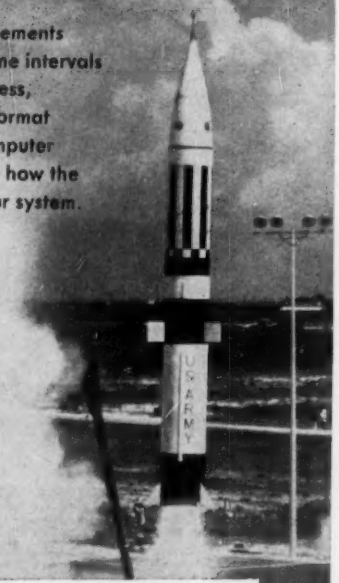
NEXT QUESTION . . .

HOW DOES IT PERFORM?

The RADAR QUANTIZER Provides Answers

By utilizing the RADAR QUANTIZER®, the Army Ordnance Corps can track the Pershing missile in flight with a position plot resolution of ±2½ feet — a resolution heretofore impossible. The Quantizer, developed under contract of the Army's Diamond Ordnance Fuze Laboratories, is a millimicrosecond time interval meter. It converts the radar electrical signals into digital code format and feeds a storage tape, *as fast as the dynamic data occurs.* As a result, engineers can follow the missile's exact flight path on the ground with the aid of digital computing equipment — making optimum use of the radar equipment's full capability, down to the Quantizer's instantaneous resolution of ±10 millimicroseconds!

If you have data processing requirements where it is desirable to measure time intervals down to ten millimicroseconds or less, and read the result out in digital format *while the data occurs,* contact Computer Equipment Corp. for full details on how the QUANTIZER can be applied to your system.



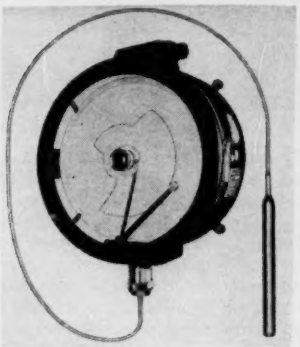
Computer Equipment Corp.

11612 W. OLYMPIC BLVD., LOS ANGELES 64, CALIF.

GRANITE 8-0464 TWX WLA 6650

CIRCLE 109 ON READER-SERVICE CARD

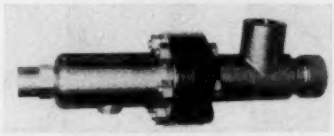
TEMPERATURE CONTROLS



Three new models of automatic programming, recording temperature controls include Model RCP potentiometer-type proportioning instrument; Model RCSS 2-point control; Model RCL adjustable-differential recorder-controller especially designed for extra long switch life.—*Partlow Corp.,* 540 *Campion Rd., New Hartford, N. Y.*

CIRCLE 275 ON READER-SERVICE CARD

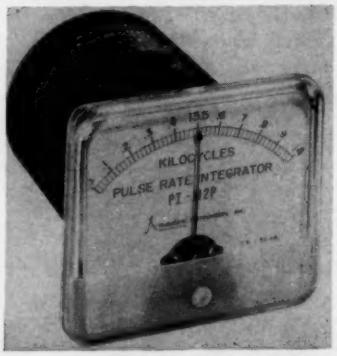
VALVES



Six new valves for control, regulating and relief in industrial hydraulic systems are available for operating pressures up to 3000 psi. Applications include boiler testing.—*Besler Corp.,* 4053 *Harlan St., Emeryville, Oakland* 8, *Calif.*

CIRCLE 276 ON READER-SERVICE CARD

FREQUENCY DEVIATION METER



New Series PI-111 Pulse Rate Integrator for monitoring power line frequencies, turbine flow sensors, tachometers, rotating machinery, etc. features input sensitivity as low as 10 mv rms. Models available to indicate 57 to 63 cps and 380 to 420 cps, with center frequencies from 50 cps to 50 kc.—*Anadex Instruments, Inc.,* 14734 *Arminta St., Van Nuys, Calif.*

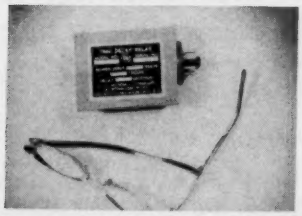
CIRCLE 277 ON READER-SERVICE CARD

MATERIALS TESTING SYSTEM

New testing system consists of Model LF6566 loading machine, Model FGE5035 control center, and associated equipment (Model RH6568 resistance heating cart, Model HPS-6571 hydraulic power supply, etc.). System is capable of imposing both temperature and load (or strain) of programs on test specimens, and simultaneously recording all 3 variables as functions of time as well as plotting load-strain curve.—*Research, Inc., Box* 6164, *Edina Sta., Minneapolis* 24, *Minn.*

CIRCLE 278 ON READER-SERVICE CARD

TIME DELAY RELAY



New Model 591 plug-in, electronic time delay (intervals 0.003 to 300 sec) with instant recycle is available in single-and double-pole double-throw models. Uses cold-cathode tube. Time delays can be fixed or adjustable.—*G. C. Wilson & Co., Box* 5525, *Huntington, W. Va.*

CIRCLE 279 ON READER-SERVICE CARD

5,000-PSI CONTROL

New "D" series pressure controls (operating range 500 to 5000 psi) are available in 3 models: Type DXA-21 minimum operating differential 450 psi; Type DXA-521 minimum differential 200 psi; Type DXS minimum differential 150 psi. External adjustment, visible dial, sealed mercury contact with visible on/off circuit position. Bulletin 0-21.—*Mercoid Corp.,* 4201 *Belmont Ave., Chicago* 41, *Ill.*

CIRCLE 280 ON READER-SERVICE CARD

THE MOST

10MC SOLID-STATE COUNTER-TIMER
TSI* Model 365 APTI®METER

FOR THE LEAST

—only $2,650.
bench or rack!

Highest sensitivity. *Three* identical amplifiers — Unique TSI level-sampling design!

•

Greatest Flexibility *Every* counter-timer-frequency function — including programmable function, time-base, and attentuation.

•

Most Compact. Smallest, lightest 10MC package available — coolest-running, too!

Extreme Reliability. *Completely* solid-state design employs "sophisticated simplicity" to reduce semiconductor count, provide wider margins!

•

Ideal Readout. *Seven* in-line NIXIES, no interpretation, no ambiguity — easy on the eyes!

•

Completely Compatible with all standard frequency extenders!

WRITE TODAY FOR COMPLETE SPECIFICATIONS

*Manufacturers of the Ultra-reliable, ultra-popular, solid-state Model 361 Apti-Meter . . . at $1645., the *most* for the *least* at 1MC!

TSI TRANSISTOR SPECIALTIES INCORPORATED
Sophisticated Digital Instrumentation
TERMINAL DRIVE, PLAINVIEW, NEW YORK • WELLS 5-8700

CIRCLE 110 ON READER-SERVICE CARD

M176
Digital
Indicator
&
Printer

M243
Digital
Indicator
&
Recorder

HIGH ACCURACY TRANSDUCER INSTRUMENTATION SYSTEMS

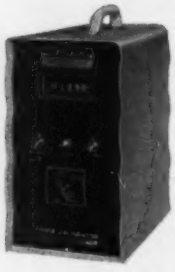
- *Multi-Channel*
  Strain Gage Plotters
- *Weighing Systems*
- Thrust Measuring Systems
- *Digital Indicators*
- Data Loggers
- *Calibration Equipment*

20 Channel
Per Second
Strain Gage
Plotter

FOR . . .

LOAD CELLS

- Tank, Hopper and Batch Weighing
- *Thrust Measurement*
- Load Cell Calibrators
- Rocket Engine Weight and C.G.



M170
Load Cell
Calibrator

STRAIN GAGES

- Multi-Graphic Plotters
- Data Loggers

THERMOCOUPLES

- Data Loggers
- Segmental Recorders

PRESSURE TRANSDUCERS

- Readout and Control Systems
- Calibrators

For specific information on any type of Gilmore System, write Dept. S

GILMORE
Instrumentation Systems for Industry and Science
INDUSTRIES, INC.
13015 Woodland Ave. • Cleveland 20, Ohio • RAndolph 1-6400
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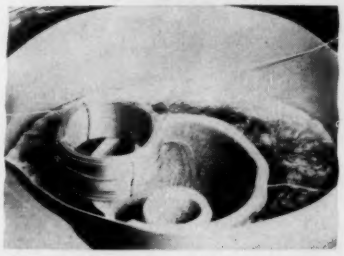
CIRCLE 111 ON READER-SERVICE CARD

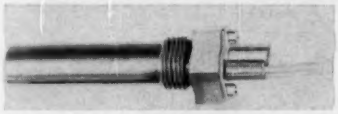
GAS CHROMATOGRAPHY TUBING



New tubing for all types of gas chromatography columns—capillary, miniature and packed—has following advantages: non-magnetic characteristics, excellent corrosion resistance and heat transfer properties, high strength and durability, and ease in bending and fabricating. Bulletin 110, *"Tubing for Gas Chromatography,"* available.—*Superior Tube Co.*, 1564 *Germantown Ave., Norristown, Pa.*

CIRCLE 281 ON READER-SERVICE CARD

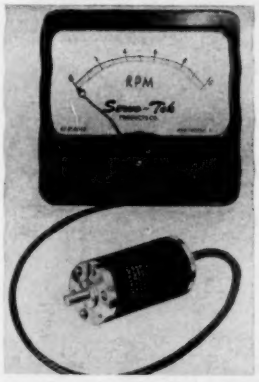
WELL-MOUNTED THERMOSTAT



New Model SX339 Tempswitch is mounted in special stainless steel well for liquid immersion; switch can be removed from well without disturbing fluid. Top temp is 700°F. Switch extends about 2.5" below the hex., is hermetically sealed. Has tamper-proof feature for adjusting screw.—*Scaico Controls, Inc.*, 210 *Taylor St., Riverside, N. J.*

CIRCLE 282 ON READER-SERVICE CARD

LOW-SPEED TACHOMETER

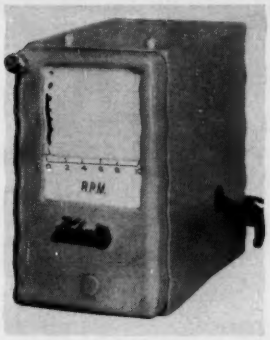


New tachometer indicates speeds of 10 rpm and lower without annoying pulsations and with accuracy of better than 2% of full scale. System is self-powered with low-torque dc generator having virtually unlimited brush life. Catalog available.—*Servo-Tek Products Co.*, 1086 *Goffle Rd., Hawthorne, N. J.*

CIRCLE 283 ON READER-SERVICE CARD

ICS NEW INSTRUMENTS

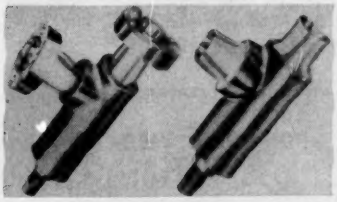
RECORDING TACHOMETER



New Model 024 Transi-Tach transistorized tachometer has built-in strip chart recorder with range of scales. Records speed, flow, or frequency within 2% of full scale.— *Kahn & Co., Inc., Box 516, Hartford 1, Conn.*

CIRCLE 284 ON READER-SERVICE CARD

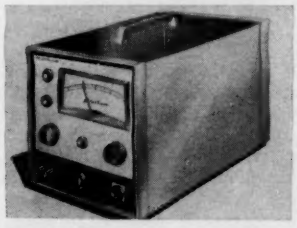
HIGH VACUUM VALVE



New 300 series stainless valve for high vacuum, all-metal systems where organic material cannot be tolerated provides vacuum seal with minimum pressure, manual operation. Operates in a pressure range from atmosphere to below 10^{-10} mm hg.—*Kane Engineering Labs., 460 Cambridge St., Palo Alto, Calif.*

CIRCLE 285 ON READER-SERVICE CARD

STRAIN GAGE AND READOUT

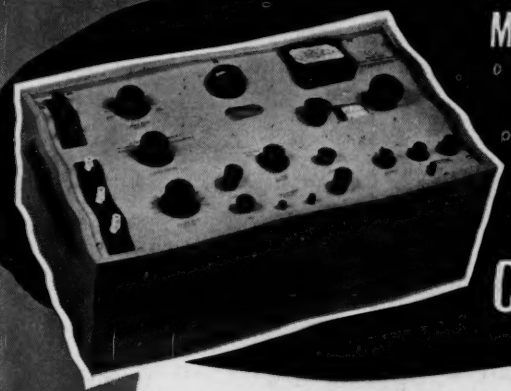


New Model SG2 resistance strain gage (range ±0.003 in/in; gage length 1.25".) is designed for repetitive measurement of strain or unit elongation. Model BCR1-0 bridge control readout operates on 110-v ac or battery.— *Statham Instruments Inc., 12401 W. Olympic Blvd., Los Angeles 64, Calif.*

CIRCLE 286 ON READER-SERVICE CARD

from

Instrument Calibration HEADQUARTERS

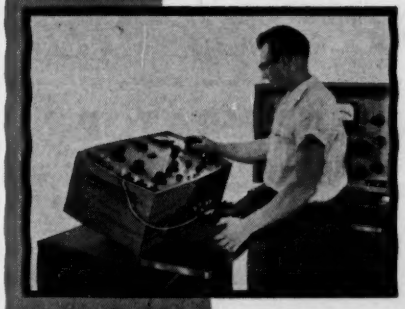


Measures Precise AC-DC Voltage & Current

Model 1605 $2450.

A Self-Contained Laboratory Standard Facility

The Model 1605 AC-DC Calibration/Transfer Standard is a multi-function instrument capable of measuring AC and DC voltage and current up to 1500 volts and 15 amperes. It includes a precision four-digit readout potentiometer, laboratory standard cell, precision voltage multipliers, precision shunts hermetically sealed in oil, light beam galvanometer, AC monitoring meter, thermal converter and all necessary batteries and controls. DC measurements utilize the potentiometer or the potentiometer in conjunction with the voltage multipliers or shunts. For AC measurements the potentiometer and/or multiplier-shunt arrangement is used with the compensated AC-DC transfer element.



LIMIT OF ERROR

DC: 0.05% with correction factors; 0.1% direct reading.

AC: 0.065% with correction factors; 0.13% direct reading.

(AC accuracies are to 50 kc on most ranges.)

For Owners of the RFL Model 829 AC-DC Instrument Calibration Standard

The Model 1605 may be used in conjunction with the Model 829 to calibrate instruments having greater accuracy requirements than that supplied by the Model 829 alone. The Model 1605 may also be used to calibrate the Model 829. The 829/1605 combination provides a calibration system which will handle your requirements, for current and voltage measurements to an accuracy of better than 0.1%, from DC to 400 cps.

Performance is rigidly guaranteed. Price is net, f.o.b. Boonton, N.J. and subject to change without notice.

SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

RFL Radio Frequency LABORATORIES, INC. Boonton, New Jersey, U.S.A.

CIRCLE 112 ON READER-SERVICE CARD

DISPLACEMENT TRANSDUCERS

with **BUILT-IN SOLID STATE** *circuitry*

To permit dynamic measurements with micro-inch resolution

SPECIFICATIONS

Excitation: to 24 VDC

Range: ±.050" to ±50"

Scale Factor: to 100 V/in. DC

Linearity: 0.5 %

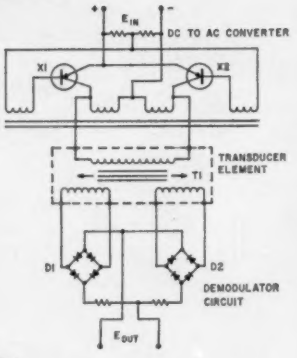
Dynamic Response: exceeds 1000 CPS

Resolution: infinite

Stability: 0.1 % F.S.

Temperature: to +275°F

SEND FOR DATA



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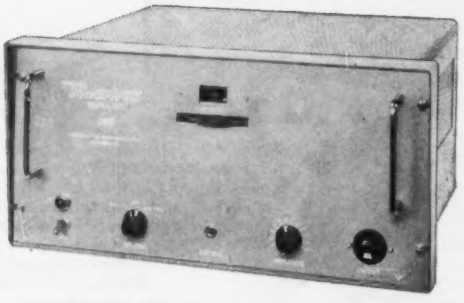
NEW Powertron

AC ELECTRONIC GENERATOR

MODEL 150 $525.00

PRECISION AC POWER SUPPLY FOR LABORATORY & PRODUCTION USE



SPECIFICATIONS

Power Output	160 V.A.	Total Distortion	Less than 1%
Fixed Frequency	400 CPS (other freq. avail.)	Regulation	Less than 1%
Variable Frequency	350-450 CPS	Operates with load of any power factor	
External Frequency	50-4000 CPS	Small size	8¾" x 19" Panel

Also Available — Model 250 — 250 VA Power Output

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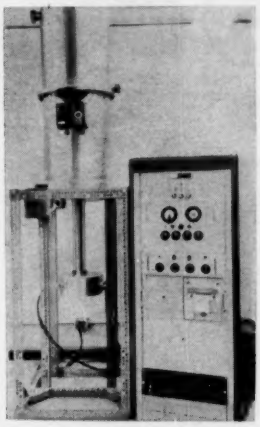
55 EAST 11th STREET • NEW YORK 3, N. Y.

CIRCLE 114 ON READER-SERVICE CARD

MOISTURE-DENSITY CONTROL



Four new Qualicon instrumentation systems are designed for continuous measurement and control of moisture and density of *materials on conveyor belts, in pipes, etc.* Model 502 measures bulk density of solid materials either on a *conveyor belt* or in a *bin or hopper;* Model 507, % moisture of solid materials on a *belt* or in a storage *facility;* Model 504, specific gravity of solutions and slurries in pipes or tanks; Model 509, % moisture of liquids or slurries in a process loop or in a tank.—*Nuclear-Chicago Corp., 359 E. Howard Ave., at Nuclear Dr., Des Plaines, Ill.*

CIRCLE 287 ON READER-SERVICE CARD

PORTABLE VIBRATION METER

New battery-operated Vibration Meter, Type PR-9252, with high-gain, transistorized circuitry, reads peak amplitudes of both absolute and relative vibration directly. Readings are in microns over its 5-cps-to-1200-cps frequency range. It has a measuring range from 0 to 1000 μ value (0.039") in 5 steps, and a sensitivity down to 0 to 10 μ full scale (0.00039").—*Korfund Co., Inc., Dept. 35A5, Cantiague Rd., Westbury, N. Y.*

CIRCLE 288 ON READER-SERVICE CARD

FOR MORE INFORMATION ON PRODUCTS LISTED CIRCLE NUMBERS ON READER SERVICE CARD & MAIL

Twin Seal Pressure Test Unit

Buy one unit . . .

. . . do THREE jobs!

1. Portable Testing
2. Bench Comparator Testing
3. Bench Dead Weight Testing

Pump suitable for any pressure to 10,000 psi. Complete fittings to service all pressure instruments.

TWIN SEAL Pressure Test Unit arranged for portable testing. Weight filled with oil approximately 11⅓ lbs.

TWIN SEAL Pressure Test Unit arranged for bench work with test gage. Precision pressure adjustment. Mounted on short drip pan.

TWIN SEAL Pressure Test Unit arranged for dead weight testing. Eight models for dead weight testing. Pressure ranges 2000, 3000, 5000 and 10,000 psi Mounted on drip pan.

NEW fully illustrated catalog on TWIN SEAL Pressure Test Unit.

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MANSFIELD & GREEN

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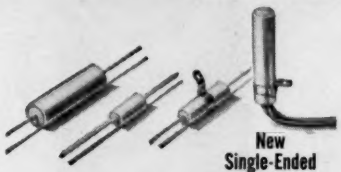
CIRCLE 115 ON READER-SERVICE CARD

CERAMIC-JACKETED RESISTOR

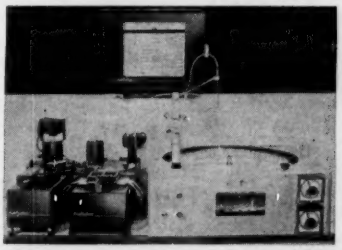


New Single-Ended Tubeohm

New style of ceramic jacketed wire-wound Tubeohm resistor has flexible, insulated leads issuing from just one end of resistor to provide complete insulation with no exposed terminals. New enclosed Model E miniature rheostat is now available in 23 popular values. Bulletin 157.—*Ohmite Mfg. Co.*, 3638 *Howard St., Skokie, Ill.*

CIRCLE 289 ON READER-SERVICE CARD

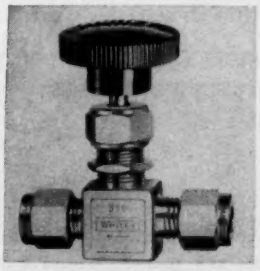
AUTOMATIC SAMPLER



New 2-speed proportioning pump and automatic sampler extend scope of laboratory applications for Technicon AutoAnalyzer. This continuous flow system automates each step of chemical analysis now performed manually, including measuring, mixing, purifying, processing, comparing and recording. Reproducible results can be obtained down to parts per billion with precision of ±1%.—*Technicon Controls, Inc., Research Park, Chauncey, N. Y.*

CIRCLE 290 ON READER-SERVICE CARD

CONTROL VALVES



New series fingertip control valves in brass and type 316 stainless steel are supplied with Swagelok connections for ¼" OD tube sizes and male pipe connections. Available in straight and angle pattern; Series 1 valve has 3000 psi pressure rating with 0.172" orifice dia.—*Whitey Research Tool Co.*, 5525 *Marshall St., Oakland* 8, *Calif.*

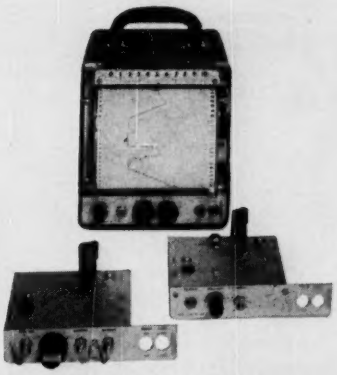
CIRCLE 291 ON READER-SERVICE CARD

VARIAN

Potentiometer

RECORDERS

Best all-purpose recorders because . . .



MULTI-RANGE INPUTS MAKE THEM

FLEXIBLE

Nine full-scale voltage ranges from 10 mv to 100 v d. c. are switch-selected on the B-1 input chassis, adapting the Varian G-11A to almost any recording need. Other interchangeable chassis let you use the G-11A for temperature recording from −200°C to +1500°C or 1mA current recording. The G-11A is portable—goes anywhere. And it's compact—never in the way.

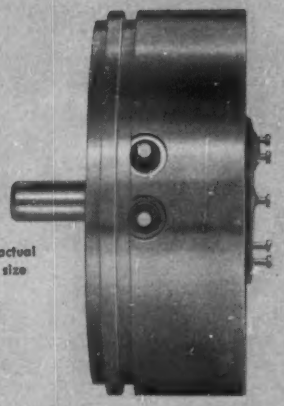
1% accuracy; 1 second full-scale balance; chart speeds from ⅛"/hour to 8"/minute; rack mounting available. A wide range of options and accessories. Complete details and specifications from the Instrument Division.

VARIAN associates

PALO ALTO 27, CALIFORNIA

CIRCLE 116 ON READER-SERVICE CARD

*OPTISYN



a unique optical shaft position encoder for servomechanisms, data reduction, navigation systems, programmed control systems

*Miniature size (2.312 dia. by 1⅝") with no sacrifice in resolution

*Instantaneous interrogation

*Low torque — will not load shaft

*Reliable — low power photocircuit and absence of moving contact insure long life and high reliability

*Economy —moderate cost, extensive life, and lack of required maintenance reduce overall control system costs

For details on standard OPTISYNS get Bulletin #604.

SPECIAL DESIGNS

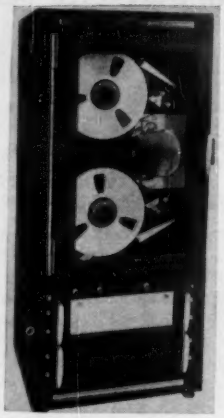
OPTISYN Gimbal Angle Readout Encoder — the first digital transducer specifically for inertial guidance or navigation platforms. Provides direct digital readout. Lightweight. Convenient shape and size will fit available space. *For details get Bulletin #606.*

OPTISYN Incremental Pickoff for readout of integrating accelerometers. High reliability and basic versatility make it ideal for this very exacting requirement. Available for size 35, 25 and 16 accelerometers. *For details get Bulletin #605.*

DRC **DYNAMICS RESEARCH CORPORATION**
38 Montvale Ave., Stoneham, Mass.

CIRCLE 117 ON READER-SERVICE CARD

DIGITAL TAPE TRANSPORT



New Model DT 10 low-speed digital tape transport will read, write or read after write from 0.1 to 15 ips in specifically selectable speeds or continuously variable speeds, controlled manually or remotely for any type computer format. Tape speed settings are held to within ± ¼% independent of line voltage and frequency.—*Shepherd Industries, Inc.*, 103 *Park Ave., Nutley* 10, *N. J.*

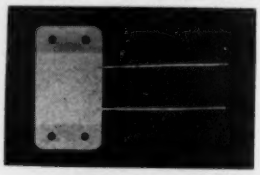
CIRCLE 292 ON READER-SERVICE CARD

THERMOMETER ENTRY PORT

New ASCO 10/30 adjustable thermometer entry port is manufactured from Telflon and consists of high vacuum O-ring seal, both inside and outside, permitting use at pressures as low as 10^{-9} mm Hg, and temperatures as high as 500°F. Eliminates expensive ground joint thermometers. —*Arthur F. Smith, Inc.*, 311 *Alexander St., Rochester* 4, *N. Y.*

CIRCLE 293 ON READER-SERVICE CARD

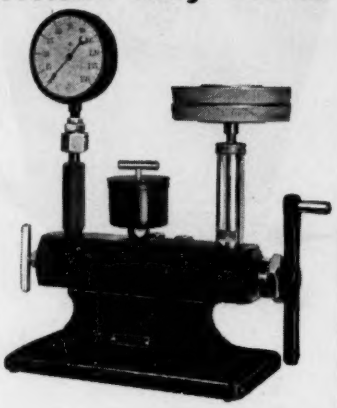
RESISTANCE THERMOMETERS



Two new transducers APM-50 with 50-ohms nominal resistance and APM-100 with 100 ohms nominal resistance permit surface temperature measurements over a usable range from absolute zero to 2000°F. AMP-100-1 can be impregnated to provide greater moisture resistance for use near room temperature.—*Arthur C. Ruge Associates, Inc., Hudson, N. H.*

CIRCLE 294 ON READER-SERVICE CARD

AMTHOR Dead Weight Pressure Gauge TESTER



Designed for simplicity and compactness. Incorporates newest refinements and improvements in various ranges up to 10,000 P.S.I. Accuracy of 1/10 of 1%.

ALSO BI-FLUID MODEL USING WATER AS PRESSURE MEDIA. ADAPTABLE FOR GASES.

AMTHOR
Testing Instrument Co., Inc.
45 Van Sinderen Ave., Brooklyn, N. Y.

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Surface temperatures within ± 0.2° F!

A+ THERMOPHIL thermistor Resistance Thermometer

- every probe built to specifications with compensating network; fully interchangeable
- spring-mounted tip for constant surface pressure
- calibration allows for heat loss up probe shank
- full reproducibility
- battery or AC powered

$246.00 as illustrated
Write for Bulletin

A+® **Atkins Technical Inc.**
1276 W. Third St.
Cleveland 13, Ohio
temperature and humidity instrumentation

CIRCLE 119 ON READER-SERVICE CARD

New INDICATING INTEGRATOR

High sensing rate handles short-run batches, fast-changing flows

Newest addition to rotameter instrumentation . . . Brooks' MPT-53 Indicating Integrator. Capable of a high sensing rate—20 to 60 counts/min. —the MPT-53 is ideally suited to operations involving short-run batches or rapidly fluctuating flows. It can be used "as is," or with supplementary remote, predetermining, or tape- or card-printing counters, for virtually any automatic batching or accounting function based on flow.

Operating through a unique magnetic position converter, the unit gives an accurate readout in precise linear relationship to the actual, calibrated flow rate of the associated rotameter. It imposes no backloading and, therefore, does not affect the accuracy of the rotameter.

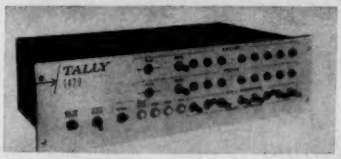
The entire instrument is enclosed in a rugged housing suitable for outdoor installation. It is unaffected by vibration, dirty or corrosive atmospheres, or extremes of ambient temperature.

Bulletin 170 gives full details. Send for a copy.

BROOKS
INSTRUMENT COMPANY, INC.
5001 W. VINE STREET
HATFIELD • PENNSYLVANIA

CIRCLE 120 ON READER-SERVICE CARD

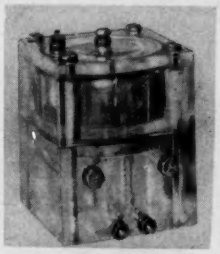
VERIFIER AND DUPLICATOR



New Model 1429 low cost tape verifier and duplicator used in conjunction with Tally punched tape readers and perforators automatically duplicates and verifies, or verifies and duplicates error free tapes in 1 operation. Failure to verify automatically stops the duplication function without punching an error character. Characters in disagreement displayed for possible correction.—*Tally Register Corp.*, 1310 *Mercer St., Seattle 9, Wash.*

CIRCLE 295 ON READER-SERVICE CARD

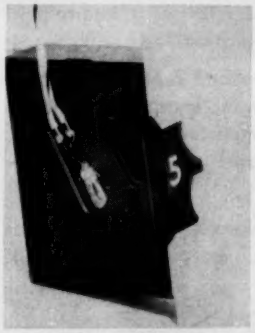
TRACE OXYGEN ANALYZER



New electrolytic cell measures traces of oxygen as low as 0.3 ppm in other gases such as nitrogen and argon. When oxygen is present in trace quantities, a voltage will be generated which is proportional to the oxygen over the electrolyte. If no oxygen is present, no voltage is produced. Cell assembly is housed in a thermostatically controlled heat chamber.—*Thermco Instrument Corp., LaPorte, Ind.*

CIRCLE 296 ON READER-SERVICE CARD

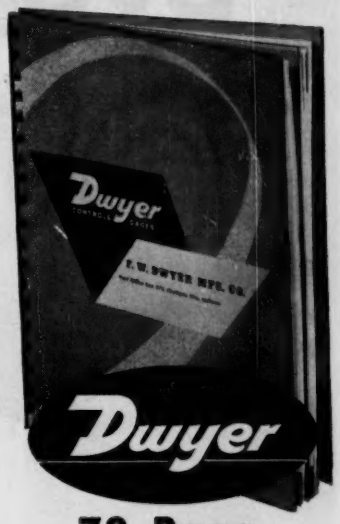
INTERNALLY-LIGHTED SWITCH



New and simplified method of providing Internal Lighting is now available for the Series 7300 Digiswitch switching element for converting visual decimal settings to computer-code electrical outputs.—*Digitran Co., 660 So. Arroyo Parkway, Pasadena, Calif.*

CIRCLE 297 ON READER-SERVICE CARD

FREE
to All Users of GAGES and CONTROLS



72-Page INSTRUMENT MANUAL

Contains:
- Illustrations and complete details of Dwyer
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  - manometers
  - air meters
  - air filter gages
  - pitot tubes
  - pressure actuated switches
  - flowmeters
  - combustion testing instruments
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CIRCLE 121 ON READER-SERVICE CARD

The first

BRIGHTNESS PYROMETER

which is fully

AUTOMATIC *and* CONTINUOUS

PYRO-650*

for temperature measurement, recording and control in the ranges from 1100°F to 7200°F and 600°C to 4000°C.

Brightness pyrometers are widely used for non-contacting, high temperature measurements. However, because existing devices are manually operated, their use has been limited to intermittent temperature measurements of short duration.

Now, PYRO-650 provides the accuracy and repeatability of a Brightness Pyrometer in a fully automatic instrument which is ruggedly designed for continuous temperature measurement, recording and control in plant environments as well as laboratory applications.

IDL also manufactures PYRO-EYE*, a two-color optical pyrometer which offers special advantages for some types of application.

*Trade Mark of Instrument Development Laboratories, Inc.

For complete information write for brochure.

INSTRUMENT DEVELOPMENT LABORATORIES, INC.
Subsidiary of ROYAL McBEE
67 MECHANIC STREET, ATTLEBORO, MASS., U. S. A.

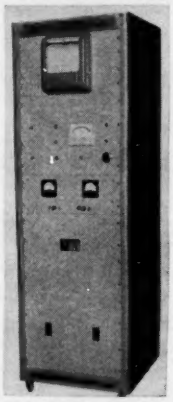
CIRCLE 122 ON READER-SERVICE CARD

TRANSDUCER EQUALIZER

"Tranqualizer," new transducer equalizer, is an analog computer. It inserts into data a complex transducer function. It virtually eliminates undesirable ringing resulting from excitation of transducer at or near natural resonant frequency, and extends system's frequency response by several octaves, allowing more accurate presentation of stimulus function.—*Data Instruments Div., Telecomputing Corp.*, 12838 *Saticoy St., N. Hollywood, Calif.*

CIRCLE 298 ON READER-SERVICE CARD

PAPER WEIGHT



New electronic basis weight paper gage is used on paper mill production lines for instantaneous detection of weight variations and moisture errors permitting corrective adjustments immediately.—*PolyTech Research Inc.*, 25 *N. Texas St., Orlando Fla.*

CIRCLE 299 ON READER-SERVICE CARD

SEALED COUNTER

New CE-41 hermetically sealed, non-reset electric counter insures maximum protection against dust, humidity, etc. Available with 4 or 5 digits; regularly operated at speeds up to 600 cpm.—*PIC Automation Controls Div., General Controls Co.*, 8062B *McCormick Blvd., Skokie, Ill.*

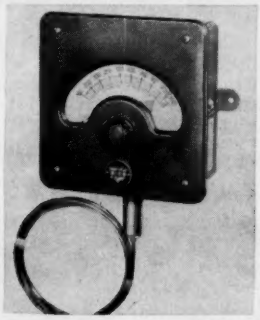
CIRCLE 300 ON READER-SERVICE CARD

ADJUSTABLE THERMOMETER

New liquid-in-glass industrial Adjust-All thermometer combines 3 features which permit complete 360° change of angle on the case and stem, plus variations of stem length. All adjustments can be made in field.—*Weksler Instruments Corp., Freeport, N. Y.*

CIRCLE 301 ON READER-SERVICE CARD

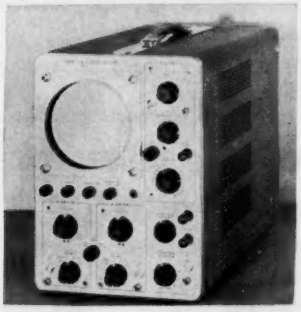
TEMPERATURE CONTROL



New compact, remote-bulb, high-temperature indicating temperature control, type E36N, is suited for ovens, test equipment, plant processes, laboratories, etc. Combines accuracy and sensitivity over wide ranges (100° to 1000°F).—*United Electric Controls Co., 85 School St., Watertown 72, Mass.*

CIRCLE 302 ON READER-SERVICE CARD

OSCILLOSCOPES



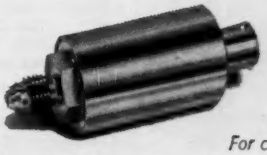
New oscilloscope, Type 516 (illustrated) is dual-trace in the dc-to-15 dc range; basic sensitivity of 50 mv/cm for each channel with 4 operating modes possible; sweep range adjustable from 0.04 usec/div to over 6 sec/div. New Type 560 oscilloscope is basically an indicator. It contains 5" crt with 3.5 kv accelerating potential, 8 x 10 cm viewing area, amplitude and sweep-time calibrator, and regulated dc supply providing 30 watts of power. The indicator accepts any 2 of 4 presently available plug-in units which drive the crt deflection plates directly.—*Tektronix, Inc., Box 500, Beaverton, Ore.*

CIRCLE 303 ON READER-SERVICE CARD

SURPRISING!

Exceptional performance characteristics of Servonic's new H-160 high pressure transducer are particularly surprising considering the small size of this potentiometer type instrument. Its 1 by 1½ inch dimensions combine with rugged design and high resolution to make it ideal for military requirements where severe environments are a problem.

Utilizing Servonic's helical bourdon assembly, the H-160 is oil damped to furnish high accuracy and long life, even under vibrations exceeding 35 g. Superior linearity over the temperature range —65° to 275° F is provided in standard construction. Individual performance characteristics have been controlled to provide accuracies of ±1.0% error band in most ranges. The unit can be readily adapted to accommodate a wide range of exotic fluids.

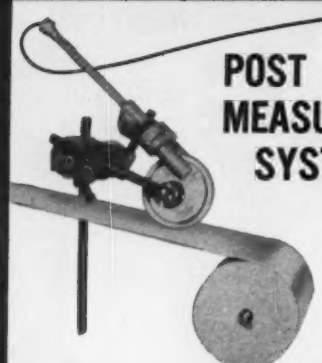


For complete specs on the H-160 and its companion, low cost industrial unit, write for Bulletin S-605.

SERVONIC INSTRUMENTS, INC.

1644 WHITTIER AVENUE, COSTA MESA, CALIFORNIA

CIRCLE 123 ON READER-SERVICE CARD



POST MEASURING SYSTEMS

Connected to any Post Decitron electronic counter, the new lineal footage device permits accurate length measurement for continuous production items.

Each time the wheel revolves, a photolight beam is broken and a count equal to one foot is registered by the counter. Varied "beam-hole", or wheel size will permit the counting of fractional parts of a lineal foot if desired. Different types of wheels provide traction surfaces for wire, rope, aluminum sheets, bar or flat steel, paper, cloth.

Used in conjunction with a Post Decitron "Preset" counter, (i.e. PW-2) a predetermined length of stock can be measured, and "marked" or cut-off as desired.

Ideal for labels and paper making where footage is most accurate measure of production.

Decitron

POST ELECTRONIC PRODUCTS

Division of Reid Brothers Company, Inc.

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TANK-O-METER

FOR MEASURING TANK CONTENTS ANY DISTANCE AWAY

TANK MAY BE BURIED, ELEVATED, OPEN, CLOSED, VENTED OR UNDER PRESSURE OR VACUUM

SEND FOR BULLETINS

Also gauges for:
Barometric Pressure (Mercury Column)
Absolute Pressure (Mercury Column)
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Differential Pressure
Inclined Manometers for draft, pressure or differential pressure.

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Constant Voltage Unit

Replaces Batteries and All Standardizing Components Including Standard Cell In

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- **Eliminates** batteries ...errors due to battery exhaustion
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- **A Precise** voltage regulator . . . max. ±.04% for ±20% voltage variation
- **Quickly Installed**... Fits present instrument battery space.
- **No Tubes** to replace

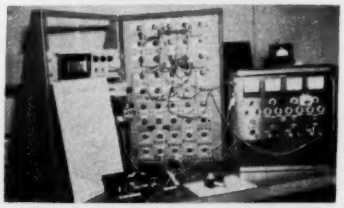
CIRCLE 126 ON READER-SERVICE CARD

PHASE SEQUENCE INDICATOR

New Models 40A and 44A portable phase sequence indicators for 3-phase power systems weigh 11 oz. each and are 2-7/8" x 1-5/8" x 4". Model 40A for 60-cycle power circuits has switch adjustment to 120, 240, and 480 v; Model 44A is for 400-cycle circuits.—*Associated Research, Inc., 3777 W. Belmont Ave., Chicago 18, Ill.*

CIRCLE 304 ON READER-SERVICE CARD

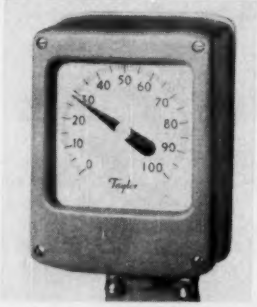
THERMO ANALYZER



New thermo analyzer, basically a passive analog computer, enables designing of cooling effect detectors in fraction of time previously required. Designs predict design parameters in advance to fit slope and shape of customer's characteristic air flow curve without necessity of extensive and expensive engineering time. Monitors total cooling effect of air flow.—Bulletin 687-17.—*Vapor Heating Corp., 6420 W. Howard St., Chicago 48, Ill.*

CIRCLE 305 ON READER-SERVICE CARD

PNEUMATIC TRANSMITTER

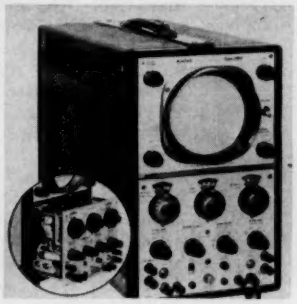


New 210T and 211T high-accuracy, low-cost pneumatic Transcope transmitters with optional servo power provide an input-to-output accuracy of ½% in the measurement of gage pressure, volumetric pressure, temperature, and volumetric load.—*Taylor Instrument Cos., Rochester 1, N. Y.*

CIRCLE 306 ON READER-SERVICE CARD

NULL-READOUT OSCILLOSCOPE

New Type 1100/700 Oscilloscope using null-balance technique is of

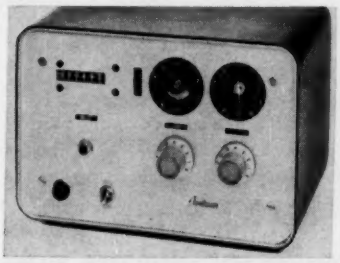


special modular design. Type 1100 Main Frame is basic, self-operable cathode-ray tube indicator; Type 700 is Dual-Channel Plug-in. Features 64 contacts for transfer of signals and voltages between frame and plug-in. —*Analab Instrument Corp. 30 Canfield Rd., Cedar Grove, N. J.*

CIRCLE 307 ON READER-SERVICE CARD

COUNTER

New predetermining laboratory and industrial counters (5000 cps) use



cold-cathode counting tubes with transistorized drive circuits. When preset number is reached, relay is actuated, and counter automatically resets to zero.—*Ardwin Microlab Inc., 21 Spencer St., Stoneham 80, Mass.*

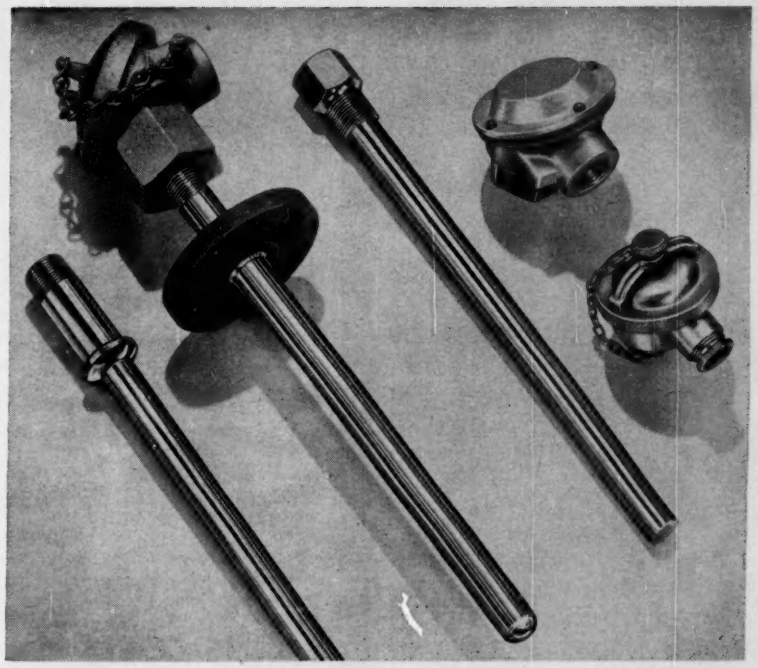
CIRCLE 308 ON READER-SERVICE CARD

LINEAR TRANSDUCER

New linear transducer, available separately, is preferably combined

with panel meter or meter-relay to form a measuring or controlling system. Sensitivity of transducer system, indicated on meter, is ± 0.005" full scale. Max readout speed, about one/sec. With constant voltage transformer, full scale meter accuracy is ± 0.0002" and reproducibility is ±0.0001".—*Assembly Products, Inc., Chesterland, Ohio.*

CIRCLE 309 ON READER-SERVICE CARD



Thermocouple Assemblies For Every Industrial Use

Thermo Electric's base metal thermocouple assemblies give consistently reliable temperature readings for ranges between —300°F. and +2200°F. We specialize in solving problems caused by chemical attack, pressure and installation difficulties . . . and offer the most complete variety of standard thermocouple assemblies in the industry. See our new 16 page catalog for the many types available.

Thermocouples

Single and multiple junction thermocouples are made of all standard thermocouple materials and gage sizes. Ceramic insulated, metal sheathed "Ceramo-Couples" are used most effectively for extended life at high temperatures or for sub-zero conditions where condensation is a problem. These temperature sensing elements have excellent resistance to moisture, petroleum products, chemical action and abrasion, and are often used without additional protection tubes. The wires used in all these thermocouples are drawn, annealed, insulated and calibrated in our own wire mill under Thermo Electric's high standards for mechanical and thermoelectric qualities.

Thermowells

The selection of over 5700 standard Thermowells includes bar stock or built-up construction, test wells and extra sensitive wells; and a variety of mounting fittings and flanges. Many construction materials available—all wells are pressure tested.

Connection Heads

Choose from six different types, including heavy duty cast iron heads, lightweight aluminum heads, and quick-opening heads. All weather proof—many sizes.

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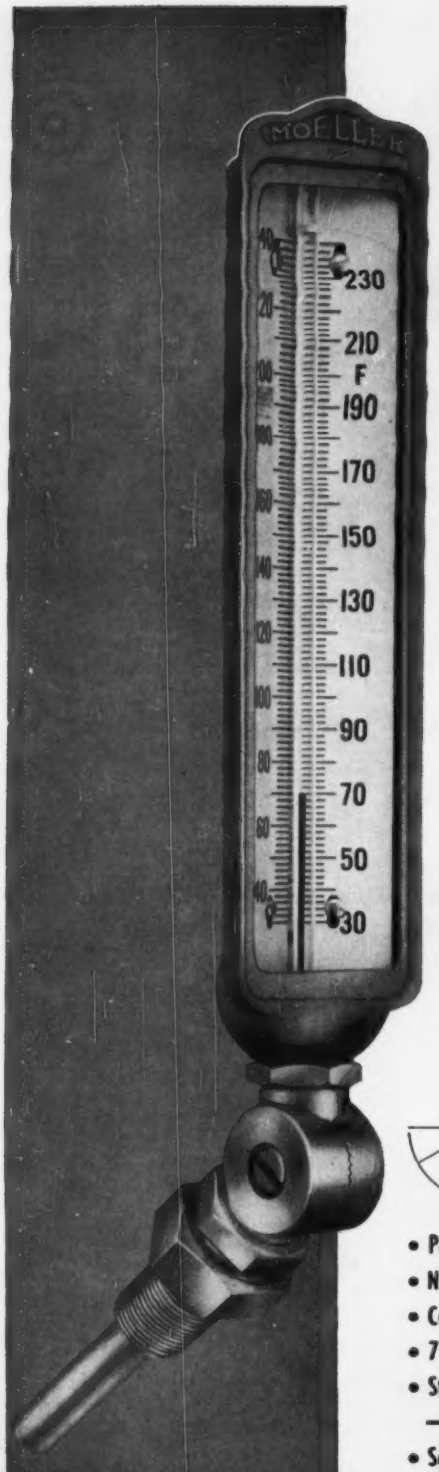

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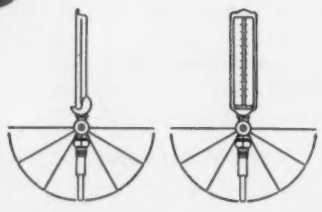

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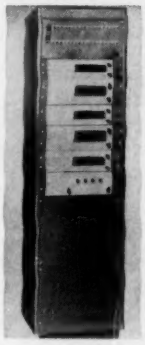
ANALOG/DIGITAL CONVERTER



New analog-digital conversion system links IBM 704 digital computer with Reeves REAC analog computer. System comprises 5 Voldicon VR11 converters, 1 control unit, and 1 fixed-data unit. Each converter contains 11-bit binary digital-to-analog and analog-to-digital channel, with sign.—*Adage Inc., 292 Main St., Cambridge 42, Mass.*

CIRCLE 310 ON READER-SERVICE CARD

PRESSURE BALANCE

Five new models of pressure balances allow calibration of pressure

gages and transducers rapid enough for production line calibration projects. Upper limits at 10,000, 15,000, 20,000, 50,000, and 100,000 psi, accuracies to 1/20 of 1%. Bulletin 4073. —*American Instrument Co., Inc., 8030 Georgia Ave., Silver Spring, Md.*

CIRCLE 311 ON READER-SERVICE CARD

DEWPOINT MEASUREMENT

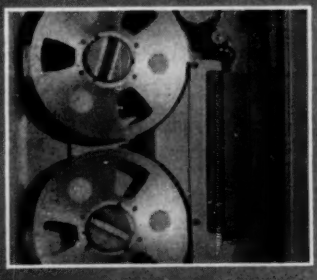
New A+ Shaw relative humidity and dewpoint instruments measure dewpoints as low as —150°C in seconds, sensitive to 1 part in 10 million. Bulletin GOVM.—*Atkins Technical Inc., 1276 W. Third St., Cleveland 13, Ohio.*

CIRCLE 312 ON READER-SERVICE CARD

HOW TO RECORD RADAR ON MAGNETIC TAPE

For needed frequency response, use Ampex's new 4-megacycle tape recorders. Magnetic tape arrests radar giving you a second look or second try in reconnaissance, tracking, simulation, evaluation or training.

Want to know more? Write Ampex at the address below.

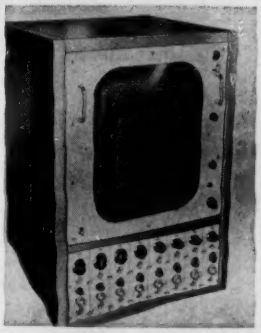


AMPEX

AMPEX DATA PRODUCTS COMPANY
Box 5000 Redwood City, California

CIRCLE 129 ON READER-SERVICE CARD

OSCILLOSCOPE AND WRITER



New monitoring oscilloscope, Model 769, simultaneously displays up to 8 waveforms on vertically-mounted 17" CR tube. It is particularly useful where multi-channel oscillographic recording systems are in use and a means of accurate event monitoring is also desired. Number of traces displayed on 'scope screen depends on number of Model 779-100 gating amplifiers used—one is required for each Y-axis input.—*Sanborn Co., Industrial Div., 175 Wyman St., Waltham 54, Mass.*

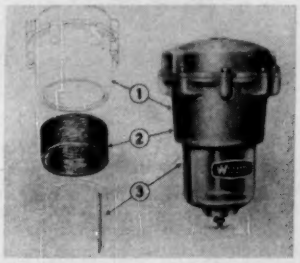
CIRCLE 313 ON READER-SERVICE CARD

PRINTER TUBES

Four new electrostatic printer tubes can print 20,000 characters per sec, or more than 10,000 lines of computer output information a minute. Applications include high speed printing photographs transmitted over telephone and telegraph lines and radio channels at a rate up to three 8½" x 11" sheets per sec.—*Industrial Components Div., Raytheon Co., 55 Chapel St., Newton, Mass.*

CIRCLE 314 ON READER-SERVICE CARD

AIR FILTER

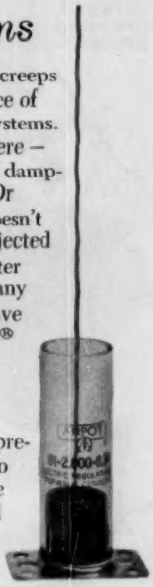


New Pure-Flo filter design offers low pressure drop, 5-micron filtration, high air flow, and full sump capacity. Available for pressures up to 250 psi and temps of 250°F. Circulars 1023, 1026.—*Wilkerson Corp., 1605 W. Girard Ave., Englewood, Colo.*

CIRCLE 315 ON READER-SERVICE CARD

When the
UNPREDICTABLE
happens

• • • the kind that creeps into the performance of newly completed systems. (Excess vibration here – slight time delay or damping needed there. Or perhaps stability doesn't match the data projected on paper.) To counter these variations, many of our customers have found the AIRPOT® an inexpensive problem solver.



AIRPOT is an air-damping dashpot; precisely constructed to operate within close tolerances. Its small size will rarely disturb a system's basic design.

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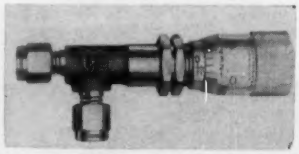
CIRCLE 133 ON READER-SERVICE CARD

MULTIRANGE METER

New Goerz Unigor 3, a Multirange Instrument (made in Germany), features high internal resistances, a-c and d-c current ranges and capacity measurement. Typical specs are 25,000 ohms/vdc and 2,000 ohms/vac, maintaining accuracies of 1.0% on dc and 1.5% on ac.—*Physics Research Labs., Hempstead, N. Y.*

CIRCLE 316 ON READER-SERVICE CARD

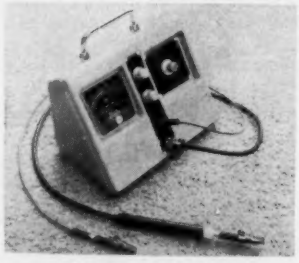
MICROMETER VALVE



New NUPRO micrometer handles which fit all NUPRO fine metering valves are set at zero with valve closed. As valve is opened, axial position of stem can be read to 1/1000". —*Nuclear Products Co., 15635 Saranac Rd., Cleveland 10, Ohio.*

CIRCLE 317 ON READER-SERVICE CARD

ELECTROSTATIC VOLTMETER



New Model 1170 ETVM electrostatic transistorized voltmeter has range capability from 0 to 50,000 v. Considered a "zero current" device because voltage-operated, it uses no electrometer tubes or high meg. resistors.—*B. K. Sweeney Mfg. Co., 6300 E. 44th Ave., Denver 16, Colo.*

CIRCLE 318 ON READER-SERVICE CARD

FOR MORE PRODUCT DATA CIRCLE NUMBER ON READER SERVICE CARD IN BACK OF BOOK

Test your BUILDING BLOCK IQ

How complete is your knowledge of digital system building blocks? Test yourself with these five questions:

1 Q. Who manufactures the highest speed digital system building blocks available today?
A. _____

2 Q. Which manufacturer utilizes a standard clamp voltage to absolutely insure the exact same voltage levels in all circuits?
A. _____

3 Q. Whose logic circuits have been evaluated time after time by independent organizations and consistently proven superior electrically to all other building blocks in use today?
A. _____

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If your answer to every question was Harvey-Wells Electronics, your building block IQ is perfect . . . If not, write today for our new technical brochure plus a complete set of specification bulletins.

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CIRCLE 134 ON READER-SERVICE CARD

JOHN E. POLIS
Senior Design Application Engineer of our Molecu-Dryer Division, reports on

LOW COST INSTRUMENT AIR DRYING

DELIVERY OF CLEAN, DRY AIR AT LOW COST for a "dry box" installation at one of our customer's plants . . . is now being accomplished with a Hayes MS Series Recirculating Molecu-Dryer. The same can be done for your instrument air system . . . where moisture causes rust, clogs up instrument ports, and creates freeze-ups in the air lines.

A NEW HAYES TYPE MSX MOLECU-DRYER has been developed to supply pure, dry air at −100°F and solve instrument air problems. An externally heated dryer, the MSX is a complete, compact, high-capacity unit featuring a simplified control system . . . makes drying and reactivating operations easy, automatic—at lowest cost ever.

SHELL AND TUBE DESIGN has been designed for safe, high pressure working ranges to 500 psig. Many other design innovations for which patents have been granted have also been applied to this and other Hayes Molecu-Dryer units. The unique feature of the new MSX, however, is the downflow stream which eliminates fluidizing of the desiccant bed, especially with high velocity flows.

SHORT CYCLES — CONTINUOUS FLOW. Dry and purge circuits of the MSX are independent and completely automatic . . . operate in alternating 4-hour cycles. Larger size Linde® Molecular Sieves are used, together with down-flow adsorption, to increase flow rates as much as 3 to 4 times that of comparable dryers with upflow stream.

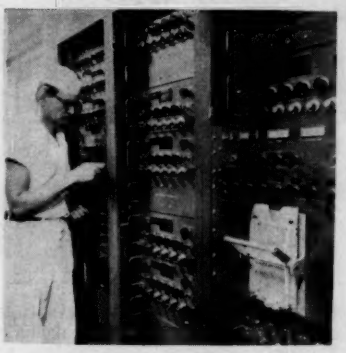
A WIDE SELECTION OF FLOW CAPACITIES and pressure ranges are available to meet your particular instrument air drying needs. Bulletin 1060C gives full details on the new Hayes Type MSX Molecu-Dryer. For your copy, write C. I. Hayes, Inc., 944 Wellington Ave., Cranston 10, Rhode Island.

C. I. HAYES, INC.
Established 1905

It pays to see Hayes for metallurgical guidance, lab. facilities, furnaces, atmosphere generators, gas and liquid dryers, Pow-R-Trol (TM) control units.

CIRCLE 83 ON READER-SERVICE CARD

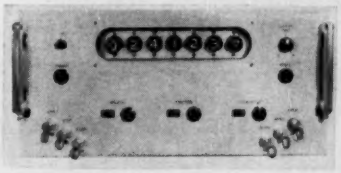
BLENDING SYSTEMS



New automatic batch and continuous blending systems can control any number of fluid or dry ingredients by combinations of standard Pottermeter transistorized modular electronic instruments. Can use information preset on Model 526 totalizer, or receive a recipe or formula on a coded punch card, tape or punched tape. Code translation memory unit is included in this type system.—*Potter Aeronautical Corp., Route 22, Union, N. J.*

CIRCLE 319 ON READER-SERVICE CARD

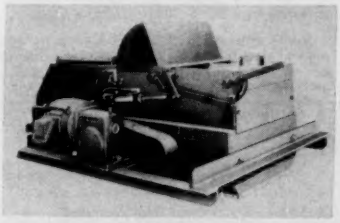
10-Mc COUNTER-TIMER



New solid-state 10 Mc programmable counter-timer meets rugged environmental conditions. Measurements include frequencies from 0 to 10 Mc and time intervals to 10 sec with an accuracy of 0.1 μsec. Short form catalog available.—*Systron-Donner Corp., 950 Galindo St., Concord, Calif.*

CIRCLE 320 ON READER-SERVICE CARD

CONVEYOR FEEDER



New improved conveyor feeder, Series C, for hard-to-handle materials is designed to feed larger sizes of flaked, fibrous and similar materials ranging up to 1½" in dia. Feeders are 2-speed single conveyor belt units; a metering gate controls bulk material being fed to belt; dribble control gate suspended above belt controls material flow from belt to containers.—*Thayer Scale Corp., Thayer Park, Pembroke, Mass.*

CIRCLE 321 ON READER-SERVICE CARD

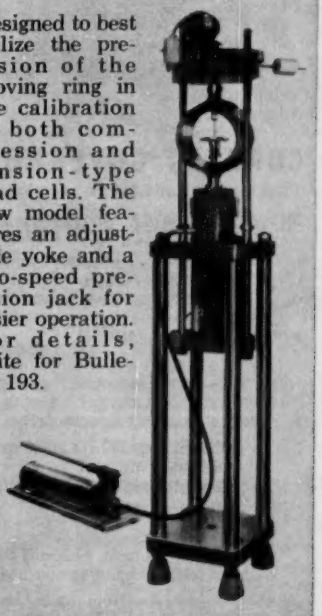
Morehouse PROVING RINGS

FOR ACCURATE LOAD CALIBRATIONS TODAY, TOMORROW ETC. ETC. ETC. ETC.

Not just accuracy, but *sustained* accuracy makes the Morehouse Proving Ring the accepted standard of force measurement. Once calibrated by the National Bureau of Standards, it is unsurpassed in dependable repeatability. The basic simplicity of its design assures retention of initial accuracy — 1/10 of 1% — over long periods of time. For full details, write for "The ABCs of ACCURACY."

NEW UNIVERSAL CALIBRATING MACHINE

Designed to best utilize the precision of the proving ring in the calibration of both compression and tension-type load cells. The new model features an adjustable yoke and a two-speed precision jack for easier operation. For details, write for Bulletin 193.



MOREHOUSE
MACHINE COMPANY
1742 Sixth Ave. • York, Pa.

CIRCLE 71 ON READER-SERVICE CARD

HARDNESS TESTING

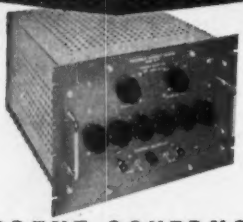
SCLEROSCOPE FOR TESTING THE HARDNESS OF METALS. PIONEER AMERICAN HARDNESS STANDARD. OVER 40,000 IN USE. (ASTM A427)

DUROMETER FOR TESTING THE HARDNESS OF RUBBER & RUBBER-LIKE MATERIALS (ASTM D676) (ASTM D1484) (ASTM D1706)

SHORE INSTRUMENT & MFG. CO., INC.
90-35 VAN WYCK EXP.
JAMAICA 35, N. Y.

CIRCLE 137 ON READER-SERVICE CARD

NORTH HILLS



CURRENT GOVERNOR
Model CS-117
for *Constant Current*

- Precision Current Source
- Gyro Torquer Supply
- Transistor and Diode Tester

High Accuracy *Excellent Stability* *Programmable*

For testing and measurement of gyros, transistors, diodes, clutches, solenoids, meters, other current sensitive devices.

- Current Range is 0.1μa to 150 ma with 6 decade multiplier
- Regulation and stability 0.002% —
- Accuracy 0.005%

In use by leading companies for gyro torquer supply, transistor avalanche test, diode PIV test, clutch testing, calibration.

Literature describing this and other constant current sources from 0.1μa to 30 amp. may be obtained from:

NORTH HILLS
ELECTRONICS, INC.
Glen Cove, Long Island, New York

CIRCLE 138 ON READER-SERVICE CARD

ICS NEW LITERATURE

CONTROL SYSTEMS

MOISTURE CONTROL system for the paper industry, Moist-O-Graph IV, is described in 4-page Data Sheet 2.9-5b.—Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Windrim Ave., Phila. 44, Pa.

CIRCLE 322 ON READER-SERVICE CARD

HYDRAULIC SYSTEMS. 6-page Bulletin I-5802 describes typical packaged hydraulic systems, installations, and advantages in process control.—Vickers Inc., Div. of Sperry Rand Corp., Detroit 32, Mich.

CIRCLE 323 ON READER-SERVICE CARD

CONTROLLERS. 6-page Bulletin DM-058 describes Series 624 Indicating Pneumatic Controllers.—Bristol Co., Waterbury 20, Conn.

CIRCLE 324 ON READER-SERVICE CARD

DIGITAL SYSTEMS BUILDING BLOCKS. Data-Bloc and Data-Pac high-speed modules, are described and application-analyzed in 8-page brochure.—Harvey-Wells Electronics, Inc., 14 Huron Dr., Natick, Mass.

CIRCLE 325 ON READER-SERVICE CARD

FREED
VARIABLE TEST VOLTAGE MEGOHMMETER NO. 1620

The Freed Type 1620 Megohmmeter is a versatile insulation resistance measurement instrument with a continuously variable DC test potential from 50 to 1000 volts.

Components such as transformers, motors, printed circuits, cables and insulation material can be tested at their rated voltage and above, for safety factor.

- Resistance — 0.1 megohms to 4,000,000 megohms.
- Voltage — variable, 50 - 1000 volts.
- Accurate — plus or minus 5% on all ranges.
- Simple — for use by unskilled operators.
- Safe — high voltage relay controlled.
- Self contained — AC operated.

OTHER MEGOHMMETERS AVAILABLE

Type 1620C MEGOHMMETER — a type 1620 with additional circuitry for testing capacitors.
Type 1020B MEGOHMMETER — a 500 volt fixed test potential. Range 1 megohm to 2 million megohms.
Type 2030 PORTABLE MEGOHMMETER — battery operated 500 volt test potential. Range 1 megohm to 10 million megohms.

Send for NEW 48 page transformer catalog. Also ask for complete laboratory test instrument catalog.

FREED TRANSFORMER CO., INC.
1707 WEIRFIELD ST., BROOKLYN (RIDGEWOOD) 27, N.Y.

CIRCLE 139 ON READER-SERVICE CARD

STEAM TEMPERATURE CONTROL. 4-page Bulletin 543 describes operation and accurate control of high steam temps and principle of desuperheater water control, and burner tilt and desuper-heater water control.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

CIRCLE 326 ON READER-SERVICE CARD

LEVEL-DETECTION devices (electronic) to handle bulk-flour dispensing in modern large-scale bakery operations are described in 2-page Bulletin L-102.—Aeronautical and Instrument Div., Robertshaw-Fulton Controls Co., Santa Ana Freeway at Euclid Ave., Anaheim, Calif.

CIRCLE 327 ON READER-SERVICE CARD

VALVES, ACTUATORS

REGULATORS AND VALVES are described in 3 spec sheets: 4-page Bulletin 136 on Type P Pressure Regulators; 2-page Bulletin 151 on Series RV200 and 201 and DV200 and 201 Valves; 2-page Bulletin 152 on Type PLV Pressure Limiting Valve.—American Meter Co., 920 Payne Ave., Erie 6, Pa.

CIRCLE 328 ON READER-SERVICE CARD

ACTUATORS. 4-page Bulletin B-1020-7 describes Series B-10 and B-20 spring and diaphragm actuators in combinations including butterfly valve, adjustable port valve, burner valve, etc.—Conoflow Corp., 2100 Arch St., Phila. 3, Pa.

CIRCLE 329 ON READER-SERVICE CARD

FLUID CONTROL VALVES—dome-loading (Domotor) regulated, cylinder, and manual operated—are described in 60-page Catalog 1500E.—Annin Co., Div., Worthington Corp., 1040 S. Vail Ave., Montebello, Calif.

CIRCLE 330 ON READER-SERVICE CARD

VALVES. 2-page Bulletin 171 describes Reliance Type LV-10 lever-actuated control valve for liquid level applications. 2-page Bulletin 113 describes Types A-163 Pressure Regulator, a precision device for lab test applications.—American Meter Co., 920 Payne Ave., Erie, Pa.

CIRCLE 331 ON READER-SERVICE CARD

AUTOMATIC CONTROL VALVE which combines features of a controller, positioner, and valve is described in 12-page Bulletin SF-755-A.—Fulton Sylphon Div., Robertshaw-Fulton Controls Co., Box 400, Knoxville 1, Tenn.

CIRCLE 332 ON READER-SERVICE CARD

AIR COMPRESSORS for industrial applications—four models rated at 25, 50, 75 and 100 hp—are described and illustrated in 6-page Bulletin 203.—Clark Bros. Co., Div. Dresser Industries, Inc., Olean, N. Y.

CIRCLE 333 ON READER-SERVICE CARD

New Stock Molded Knobs

AVAILABLE WITH OR WITHOUT SKIRTS

4 Standard Sizes

Meet MIL-P-14 Specs

MODEL RB-1250-SK Illustrated

Molded of thermosetting phenolic or urea materials. Available in 4 standard sizes with nickel plated brass inserts for ¼" or ⅛" diameter shafts. Aluminum decorative inserts or skirts, etched and filled as desired . . . various anodized finishes, plain or radially spun. Write for new catalog illustrating Rogan's complete line of stock molded knobs.

ROGAN BROTHERS, Inc.

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Specializing In Stock Molded Knobs Since 1939

CIRCLE 140 ON READER-SERVICE CARD

PHOTOGRAPHIC AUTOMATION ROBOT

35mm CAMERA—NUCLEUS OF A COMPLETE ELECTRO-AUTOMATIC RECORDING SYSTEM

ROBOT ROYAL S/Sa: 24 x 36mm, 24 x 24mm or 18 x 24mm frames; with coupled range/viewfinder (lenses from 30mm to 400mm); automatic one-by-one shots or Kinographic Sequence for bursts of 5-6 frames per second.

ROBOT RECORDER: 24 x 36mm, 24 x 24mm, 18 x 24mm or 6 x 24mm frames; without range/viewfinder. OPTIONAL: rewind knob, sequence release, reticle, reflex system for double exposing second 8 x 8mm image.

ROBOT STAR II: 24 x 24mm frames; with lumiframe viewfinder (lenses from 30mm to 150mm); single motor for 20 exposures or double motor for up to 55 exposures without rewinding.

ROBOT COMPLETE ELECTRO-AUTOMATIC RECORDING SYSTEM: Royal or Recorder Camera w/30 or 200 ft. magazine; electric booster motor; camera holder; remote release; angle bracket; transformer-rectifier; intervalometer (timer) from ¼ sec. to 24 hours.

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See your franchised ROBOT dealer or write for free illustrated brochure ICR-1.

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CIRCLE 141 ON READER-SERVICE CARD

ICS NEW LITERATURE

MANUAL OPERATOR. 2-page Bulletin 153 describes Microsen closed-loop process control instrument, Type A153 manual valve control with meter-type valve position indicator and control knob.—Aeronautical and Instrument Div., Robertshaw-Fulton Controls Co., Santa Ana Freeway at Euclid Ave., Anaheim, Calif.

CIRCLE 336 ON READER-SERVICE CARD

CONTROL VALVES. 8-page Catalog J170-1 describes Sliding Gate and Plate Control Valves for steam, water, air, oil, gas and chemicals. OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio.

CIRCLE 337 ON READER-SERVICE CARD

VALVES. 2-page catalog sheet describes the Atlas Type F and Type FS pressure reducing valves for use with steam, water, gas and air to initial pressures of 500 psi. Two 2-page catalog sheets describe No. 3850 and No. 3851 Type F pressure reducing and relief valves for water, oil, gas service to initial pressures of 4000 psi.—Atlas Valve Co., 280 South St., Newark 5, N. J.

CIRCLE 338 ON READER-SERVICE CARD

BRONZE BALL VALVE is described in 2-page Circular 611.—Lunkenheimer Co., Cincinnati 14, Ohio.

CIRCLE 339 ON READER-SERVICE CARD

TEMPERATURE

TEMP CONTROLS. 4-page Catalog G-25 describes electric and pneumatic differential expansion type temperature controls for temps to 2000°F.—Burling Instrument Co., 16 River Rd., Chatham, N. J.

CIRCLE 340 ON READER-SERVICE CARD

PYROMETER. 4-page Bulletin 10C60 describes Shawmeter automatic, two-color Pyrometer for indicating, recording or controlling temperatures.—Shaw Instrument Corp., Box 46, Latrobe, Pa.

CIRCLE 341 ON READER-SERVICE CARD

PYROMETER. 2-page Bulletin 0057 features Types CSP and CST Portable Radiation Surface Pyrometers for continuous recording and control of sheet, web and film temperatures.—Atlantic Pyrometers, Inc., 190 Warburton Ave., Hawthorne, N. J.

CIRCLE 342 ON READER-SERVICE CARD

PRESSURE, VACUUM, WEIGHT

BELLOWS TRANSMITTER. 4-page Spec S230-1 describes Bellows Differential Pressure Transmitter, indicating and non-indicating models.—Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne and Windrim Ave., Phila. 44, Pa.

CIRCLE 343 ON READER-SERVICE CARD

RUPTURE DISKS of impervious graphite, their venting capacities, gasket sizes, bolt torq specs and installation are described in 8-page Bulletin 315-2.—Falls Industries, Inc., Solon, Ohio.

CIRCLE 344 ON READER-SERVICE CARD

WEIGHING. 4-page brochure describes Ametron electronic crane scale that combines weighing and transporting. Also available, 12-page booklet, "Industrial Weighing Through Electronics."—Streeter-Amet Co., Grayslake, Ill.

CIRCLE 345 ON READER-SERVICE CARD

HIGH VACUUM EQUIPMENT is described in short-form catalog.—Hughes Aircraft Co., Vacuum Tube Products Div., 2020 Short St., Oceanside, Calif.

CIRCLE 346 ON READER-SERVICE CARD

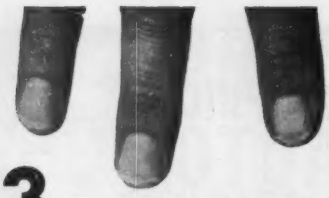
WEIGHT CALCULATOR. 4-page brochure describes DATAMATIC Weight Calculator used alongside filler lines to weigh and record weights of items on production lines of coffee, tablets, oils, drugs, etc.—Scale Specialties, Inc., Box 574, Denville, N. J.

CIRCLE 347 ON READER-SERVICE CARD

FLOW, LEVEL

PRESET TOTALIZER. 4-page Bulletin D-222 describes Model 524 automatic pre-determined counter that provides push-button control of fluid measuring, batching, mixing or blending.—Potter Aeronautical Corp., Route 22, Union, N. J.

CIRCLE 348 ON READER-SERVICE CARD



3 Reasons Why

Robbins VALVES Are the Most Economical You Can Buy

1. The only valves that can be completely serviced in less than 1 minute from the front of mounting panel without removing the valve from the line!

To service a Robbins Metering & Shut-Off Valve it is only necessary to remove the handle, loosen locknut and remove barrel assembly . . . all accomplished from the front of the panel . . . no need to disturb the line connections!

2. Single barrel assembly!

For both civilian and military installations the single barrel assembly design and construction features (barrel, spindle, spindle seals, barrel seals and seat in one unit, cleaned, lubricated, sealed for oxygen service) mean practically instantaneous renewal of service without disconnecting any plumbing.

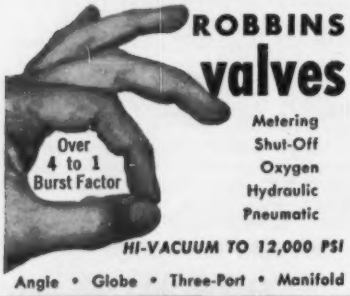
3. As many as 5000 cycles before requiring servicing!

Many Robbins Metering Valves . . . in constant use on an 8-hour a day basis for three years . . . have never required servicing, lubrication, or any parts replaced!

...And the Most Reliable!

Precision made and tested. Design capabilities, manufacturing procedures, and quality control operations at Robbins Aviation are all directed toward one objective . . . to produce a valve of the highest quality that will provide the user with the greatest reliability and the greatest economy over many years of service.

All Valves LOX Cleaned and Packaged . . . Ready for Instant Use



ROBBINS Aviation Inc.

Write today for complete color catalog and valve technical information

2350 E. 38th St., Los Angeles 58, Calif.
LUdlow 9-5221

CIRCLE 135 ON READER-SERVICE CARD

ICS NEW LITERATURE

LIQUID-LEVEL SENSOR. 4-page folder describes unitized liquid-level switch which combines an ultrasonic probe and transistorized control into integral unit.—Acoustica Associates, Inc., Gauge and Control Marketing Dept., 10400 Aviation Blvd., Los Angeles 45, Calif.

CIRCLE 349 ON READER-SERVICE CARD

PUMPS. 32-page Bulletin 553-2 on motor driven controlled volume pumps features selection data guide, materials selection charts, capacity-pressure selection tables.—Milton Roy Co., 1300 E. Mermaid Lane, Phila. 18, Pa.

CIRCLE 350 ON READER-SERVICE CARD

TOTALIZER. Two 2-page bulletins describe 60°F Barrel Flow Totalizer System and Electrical Pulse Driven Ticket Printer.—Potter Pacific Corp., Box 398, Woodland Hills, Calif.

CIRCLE 351 ON READER-SERVICE CARD

SPEED, TIME

SPEED MEASUREMENT. 4-page Bulletin 1000 describes self-generating 3-phase electric speed measurement systems.—Meriam Instrument Co., 10920 Madison Ave., Cleveland 2, Ohio.

CIRCLE 352 ON READER-SERVICE CARD

DIGITAL TIMERS. 2-page Bulletin 98 describes Chrono-log Model 8000 Digital Counters and Model 9000 Digital Timers which produce digital, decimal representation of total count or elapsed time.—Chrono-log Corp., Box 4587, Phila. 31, Pa.

CIRCLE 353 ON READER-SERVICE CARD

TURBINE SUPERVISORY instruments are described in 12-page Bulletin 3078-1. System monitors vibration, shaft eccentricity, shell and differential expansion, speed, and valve position. Also 4-page Bulletin 3077-1 details credits allowed for earlier models on replacement.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 354 ON READER-SERVICE CARD

DATA HANDLING

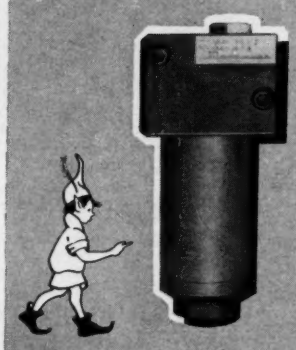
COMPUTER. 4-page Bulletin SB 0860 describes refiner's use of Bendix G-15 digital computer to compute material balances; forecast alkylation, polymerization, and outside butane requirements; analyze heat-exchanger performance, and gasoline blending.—Bendix Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif.

CIRCLE 355 ON READER-SERVICE CARD

DIGITAL DATA SYSTEMS, applications for digital tape recording techniques, and functional and block diagrams are described in 20-page brochure.—Minneapolis-Honeywell, Industrial Systems Div., 10721 Hanna St., Beltsville, Md.

CIRCLE 356 ON READER-SERVICE CARD

This is a servofilter



. . . it protects hydraulic servo systems by filtering out dirt.

Only one filter element is required for phosphate ester or standard oils . . . any flow . . . 5 or 25 micron rating.

For subplate or line mounting . . . ¼" NPTF or AND-10050-4 connections.

Dimensions, application data, and specifications are in Technical Bulletin 91415. Ask for a copy.

there's a lot of magic in B & F servo-components.

Boonshaft and Fuchs Inc.

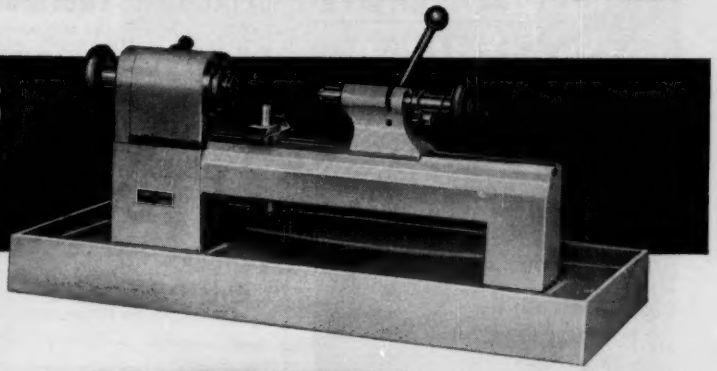
HATBORO INDUSTRIAL PARK • HATBORO • PA.

CIRCLE 136 ON READER-SERVICE CARD

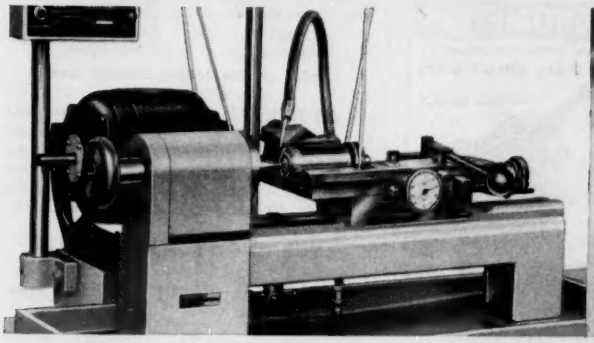
BIG NEWS FOR USERS OF INSTRUMENT LATHES

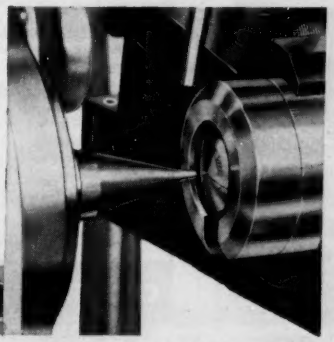
LEVIN® LATHES

PRODUCE SMALL INSTRUMENT PARTS MUCH BETTER



We present the latest in the series of Levin Instrument Lathes, a new model with a half inch collet capacity but with the same sensitivity and precision for which Levin Lathes are so well known.





Here is a typical example of work which can be done in the new Levin ½" capacity lathe. A hole .002" in diameter is being drilled in a nozzle.

Send for literature describing the ½" capacity instrument lathe and accessories.

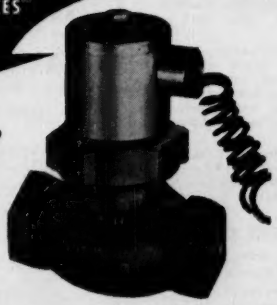
LOUIS LEVIN & SON, INC., 3573 HAYDEN AVE., CULVER CITY, CALIF.

CIRCLE 142 ON READER-SERVICE CARD

Check these prices on Gould Type M

Solenoid Valves

TYPICAL USER NET PRICES F. O. B. FACTORY



SIZE	1 to 5	100 to 499
½"	$15.40	$11.15
¾"	18.50	13.60
1"	24.25	18.50
1½"	48.00	42.40

2-Way • General Service
Packless • Normally Closed

Sizes ⅜" to 3" • Temperatures to 250° • Pressures to 400 psi • Molded epoxy resin water-proof coils • Unbreakable piston rings • No damaging hammer • Easy-off "O" ring bonnet construction in sizes ⅜" thru ¾" • High temp coils and explosion proof housings available. Immediate delivery. Ask for Bulletin 600-M.

SOME OTHER TYPES OF GOULD SOLENOID VALVES

D—Adjustable flow control, adjustable cushioning control to reduce shock, manual opening. **HV**—Four independent controls—opening, closing, flow, manual opening. **G**—Stainless, fractional ports, pressures to 1,000 psi. **GX**—All 316 stainless, fractional ports. **K**—Stainless, ½" to 2". **MDW**—Direct acting. NOTE: Special assemblies for exacting requirements.

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GOULD SOLENOID VALVES — VELVETROL

CIRCLE 143 ON READER-SERVICE CARD

WEIGH ELECTRONICALLY

Ametron® Ametron Electronic Scale systems are custom engineered to fulfill the requirements of performance that will meet your exact specifications. They are flexible instruments requiring a minimum of maintenance. Ametron Scales weigh heavy loads and print the record of weight on tape, cards, or bills of lading.

Many new features have been added to the Cabinet Model Recorders.

Write for the latest bulletin, B-20, illustrating electronic weighing systems.

WRITE TO:

STREETER-AMET COMPANY
GRAYSLAKE, ILLINOIS
U.S.A.

CIRCLE 144 ON READER-SERVICE CARD

ICS SEARCHLITE SECTION

REBUILT INSTRUMENTS

Many Temperature Controllers, Precision Indicators, Continuous Line & Multiple Point Recorders; Leeds & Northrup Speedomax, Micromax, M.H. Brown Electroniks; and other makes. Also, Strain Gauge Recorders & Potter Flow Recorders & Indicators.

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1205 Lamar St. • Dayton 4, Ohio
BA3-2241

CIRCLE 145 ON READER-SERVICE CARD

PYROMETERS
BOUGHT—SOLD—SERVICED
Immediate Shipment of Rebuilt Pyrometer Equipment From Stock
—LIST ON REQUEST—
PYRO SERVICE CO.
17121 Greeley, Detroit 3, Mich.

CIRCLE 146 ON READER-SERVICE CARD

ELECTRIC LAB TIMER

Giant 8" Dial

GRA LAB INTERVAL TIMER Automatic signalling and switching over unusually wide range of 3600 possible setting.

GRA LAB MICRO TIMER 1/10 sec. or 1/1000 min. stop clock. Remote start stop control. Write for catalog.

DIMCO-GRAY COMPANY
212 E. SIXTH ST., DAYTON 2, OHIO

CIRCLE 147 ON READER-SERVICE CARD

MEASURE RPM
WITH
STICHT TACHOMETERS
PORTABLE
AND STATIONARY
BULLETIN NO. 1048

HERMAN H. STICHT CO., INC.
27 PARK PLACE. NEW YORK 7, N.Y.

CIRCLE 148 ON READER-SERVICE CARD

Fixed Set Thermostats

ANY SIZE, ANGLE OR USE
SETTING RANGE: —35°C to 370°C
SET SENSITIVITY: ±.01°C

Guaranteed sensitivity . . . year-in, year-out reliability . . . accurate control of temperature in ovens, electronic equipment, baths, ducts, freezers, fire alarms, incubators, analytic instruments, etc. Triple distilled mercury; filled at still. Hermetically sealed with dry hydrogen at 75 psi. Calibrated to Bur. Standards accuracy. Priced 10% to 15% lower than competitive lines.

FREE CATALOGUE WRITE
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CIRCLE 149 ON READER-SERVICE CARD

SMITHS TACHOMETERS
For Precise and Rapid Measurements of
SHAFT SPEEDS CUTTING SPEEDS SURFACE SPEEDS

- **Magnetic Design** Steady readings accurate to ±0.5%
- **Self-Powered** Needs no battery.
- **Hold Button**
- **Overspeed Protection** Inherent
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- Nine Ranges

Complete Service Facilities Send for Details and Literature
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CIRCLE 150 ON READER-SERVICE CARD

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AUTOMATES • SAFEGUARDS

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POWER SUPPLIES and load analyzers are described in 6-page Bulletin B611. —Anders Electronics, Inc., Brook Rd., Needham Hts. 94, Mass.

CIRCLE 357 ON READER-SERVICE CARD

MISCELLANEOUS

ELECTRODE GLANDS. 8-page Catalog 960 describes electrode glands that pressure seal electrical leads, provide high dielectric strength and corrosion resistance.—Conax Corp., 2300 Walden Ave., Buffalo 25, N. Y.

CIRCLE 358 ON READER-SERVICE CARD

ZERO GOVERNOR. 4-page Bulletin 114 describes Reliance Type AZ Zero Governor for gas engine installations, pre-mix machines, and other gas-air applications requiring zero pressure or vacuum opening.—American Meter Co., 920 Payne Ave., Erie 6, Pa.

CIRCLE 359 ON READER-SERVICE CARD

TECH RUBBER STAMPS. 80-page catalog describes and illustrates rubber stamps of standard symbols (ASA, ASME, AIEE, IRE, NEMA, etc.)—Paper Equipment Distributing Co., Box 90, Prince St. Sta., New York 12, N. Y.

CIRCLE 360 ON READER-SERVICE CARD

GAS SURVEY RECORDER that cuts load research costs is featured in 4-page Catalog 35-1543.—Fischer & Porter Co., 713 Jacksonville Rd., Warminster, Pa.

CIRCLE 361 ON READER-SERVICE CARD

pH METER. 2-page Bulletin 706-F describes Zeromatic pH Meter, line-operated and drift free. Push-button controls.—Beckman Scientific and Process Instruments Div., Fullerton, Calif.

CIRCLE 362 ON READER-SERVICE CARD

SALT SPRAY CHAMBERS made of Lucite are described in 2-page Bulletin C-11-2. Meet mil-spec corrosion requirements.—Associated Testing Labs, Inc., Wayne, N. J.

CIRCLE 363 ON READER-SERVICE CARD

FITTINGS. 4-page Bulletin 4323B1 describes Ridg-lok flareless tube fittings of stainless for corrosion-resistant service.—Parker Fittings & Hose Div., Parker-Hannifin Corp., 17325 Euclid Ave., Cleveland 12, Ohio.

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INDUSTRY NEWS

THE FOXBORO COMPANY announces that *Charles Schwarzler* will head the new marketing division as vice president of marketing; *Henry O. Ehrisman* has been ap-

CHARLES SCHWARZLER

HENRY O. EHRISMAN

VINCENT V. TIVY

pointed vice president and U. S. general sales manager; and *Vincent V. Tivy* has been named director of engineering.

WESTON INSTRUMENTS DIVISION of Daystrom, Incorporated announces the appointment of *Harold L. Russell* as general sales manager.

SPRAGUE ELECTRIC has appointed four new senior vice presidents and four new vice presidents. Among them are *Neal W. Welch*, S.V.P., marketing and sales; *Wilbur A. Lazier*, S.V.P., technical director; *Robert C. Sprague, Jr.*, S.V.P., industrial relations; *David B. Peck*, V.P., special products; and *Carroll G. Killen*, V.P., industrial and military sales.

FISHER GOVERNOR COMPANY recently held a two-week "Sales Fundamentals" school, attended by 40 sales-

men from all over the country, and one from Japan. Personnel got a background in automatic control fundamentals.

RADIATION INCORPORATED announces that *Albert J. Morris* has been elected president of the newly formed subsidiary RADIATION AT STANFORD, comprising the former Levinthal Electronic Products, Inc. and the company's former Space Communications Division.

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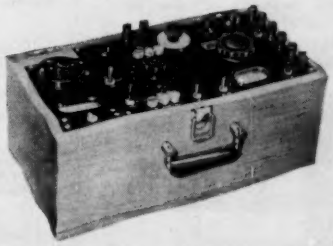

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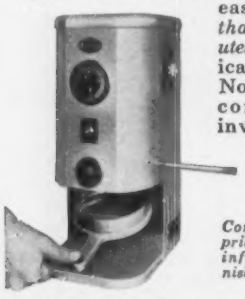

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9	29	49	69	89	109	129	149	169	189	209	229	249	269	289	309	329	349	
10	30	50	70	90	110	130	150	170	190	210	230	250	270	290	310	330	350	
11	31	51	71	91	111	131	151	171	191	211	231	251	271	291	311	331	351	
12	32	52	72	92	112	132	152	172	192	212	232	252	272	292	312	332	352	
13	33	53	73	93	113	133	153	173	193	213	233	253	273	293	313	333	353	
14	34	54	74	94	114	134	154	174	194	214	234	254	274	294	314	334	354	
15	35	55	75	95	115	135	155	175	195	215	235	255	275	295	315	335	355	
16	36	56	76	96	116	136	156	176	196	216	236	256	276	296	316	336	356	
17	37	57	77	97	117	137	157	177	197	217	237	257	277	297	317	337	357	
18	38	58	78	98	118	138	158	178	198	218	238	258	278	298	318	338	358	
19	39	59	79	99	119	139	159	179	199	219	239	259	279	299	319	339	359	
20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	

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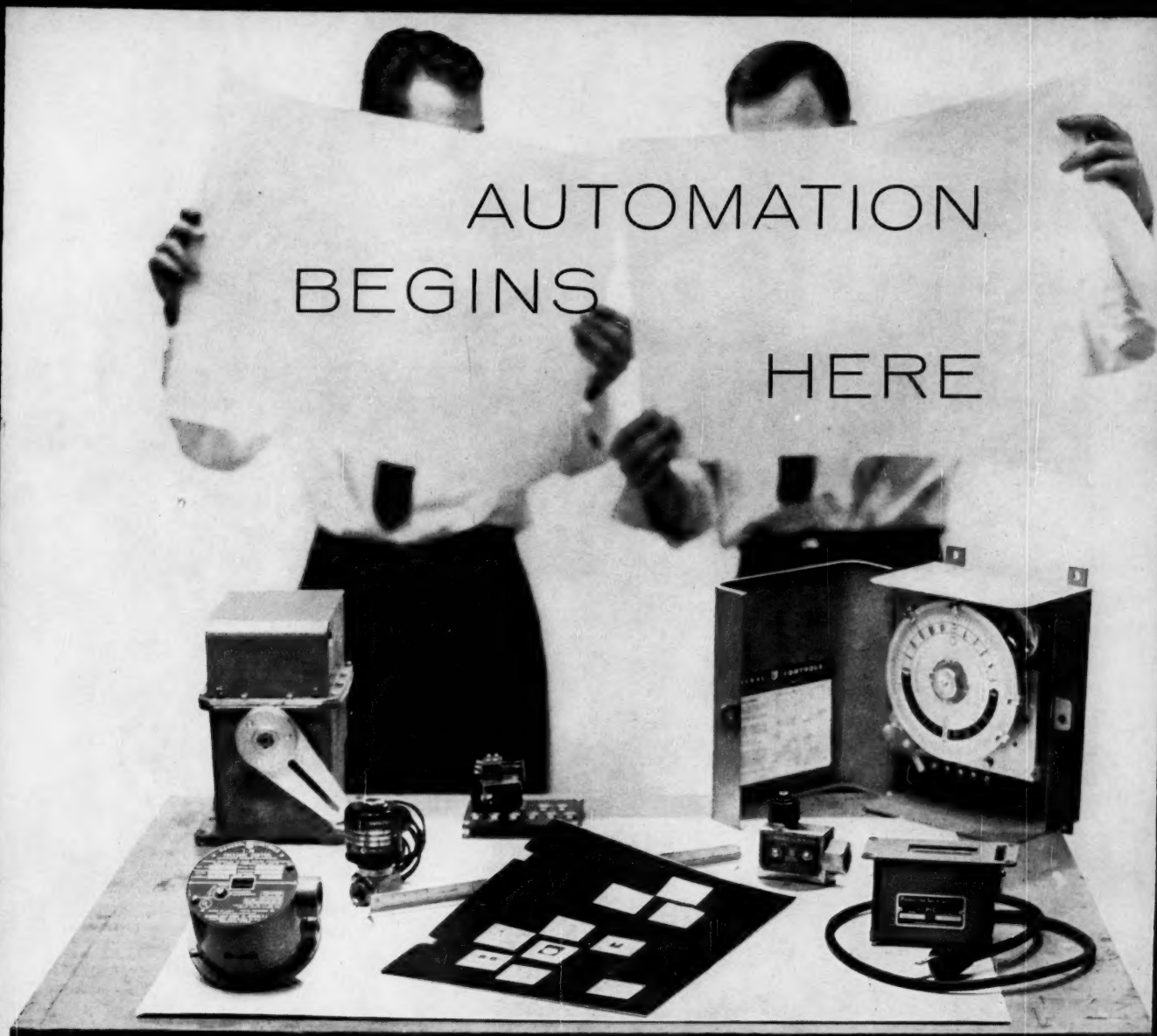

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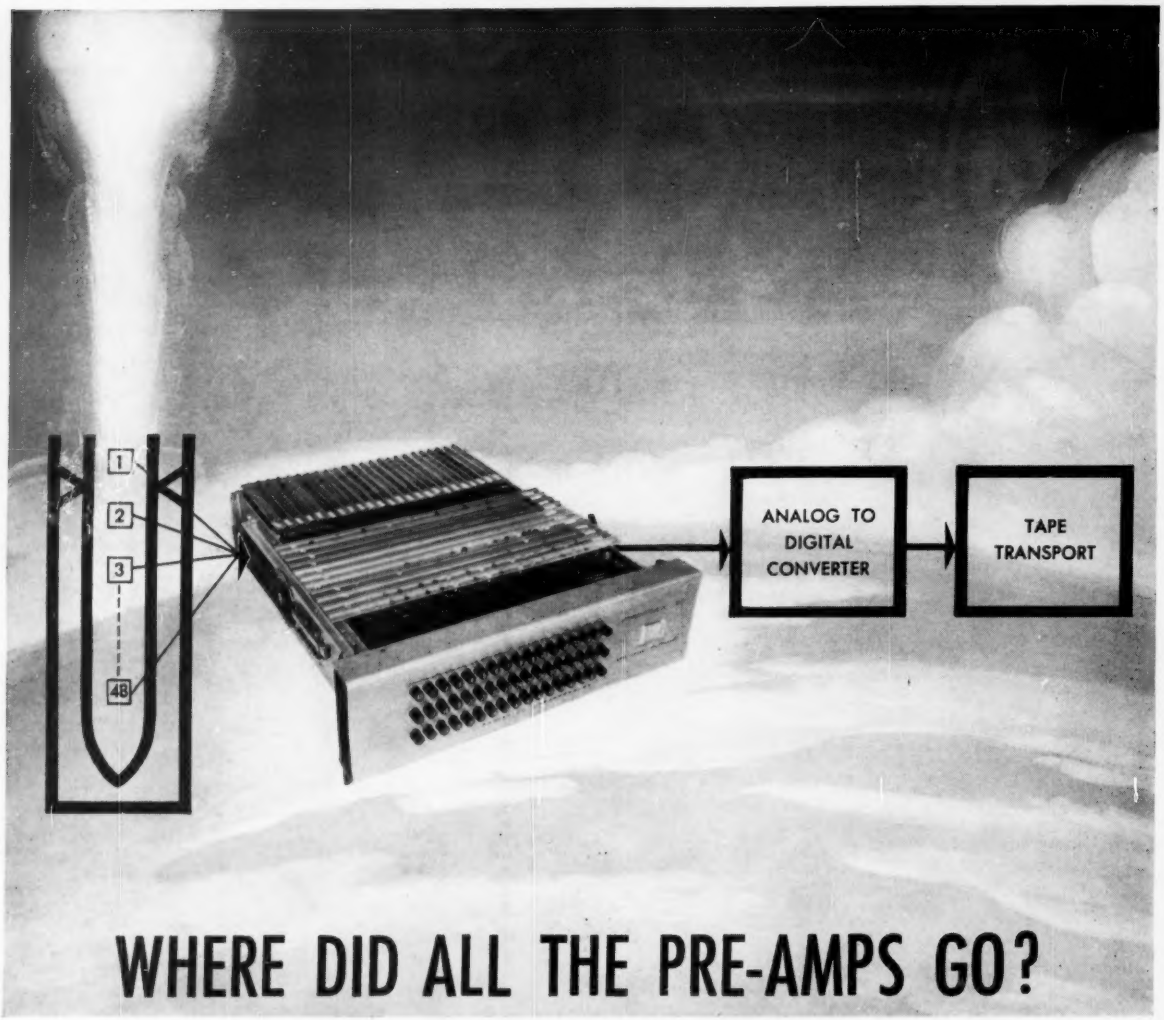

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New low-level multiplexer features high accuracy, programming flexibility in minimum space

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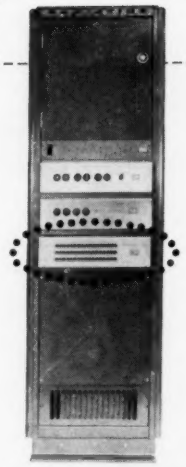
For other details on the Radiplex 89, write for a technical data bulletin to Radiation Incorporated, Dept. IC-1. Melbourne, Fla.



Circled area indicates small space (5¼" high) occupied by 48-channel Radiplex multiplexer in standard cabinet. Unit directly above Radiplex is a Radicon analog-to-digital converter.

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